SCIENTIFIC AMERICAN
No. SUPPLEMENT 856

Copyright by Munn & Co., 1892.

Scientific American Supplement, Vol. XXXIII. No. 856.
Scientific American, established 1845.

NEW YORK, MAY 28, 1892.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

A 4,000 TON FORGING PRESS.

THE substitution of hydraulic presses for powerful steam hammers for the forging of large masses of steel is now no longer a matter of discussion. It is found that the work of the press is more regular, homogeneous, and rapid, and, on another hand, that the cost of establishment is notably less than that of steam hammers. Finally, the difficulties met with in the installation of the foundations and anvil beds increase in such a measure when the weight of the hammers is increased that we have at present reached the limit of power that may be given them, while that of presses cannot as yet be foreseen. These various considerations have decided all the leading metallurgical establishments to install forging presses alongside of the hammers that they already possessed. The Company of Forges of Chatillon-Commentry has not been the last in France to do this. The 4,000 ton press that it has installed in its Saint Jacques works, at Montlucon, is the most powerful apparatus that at present exists in France, and one of the most powerful in the world.

The following is a description of the press:

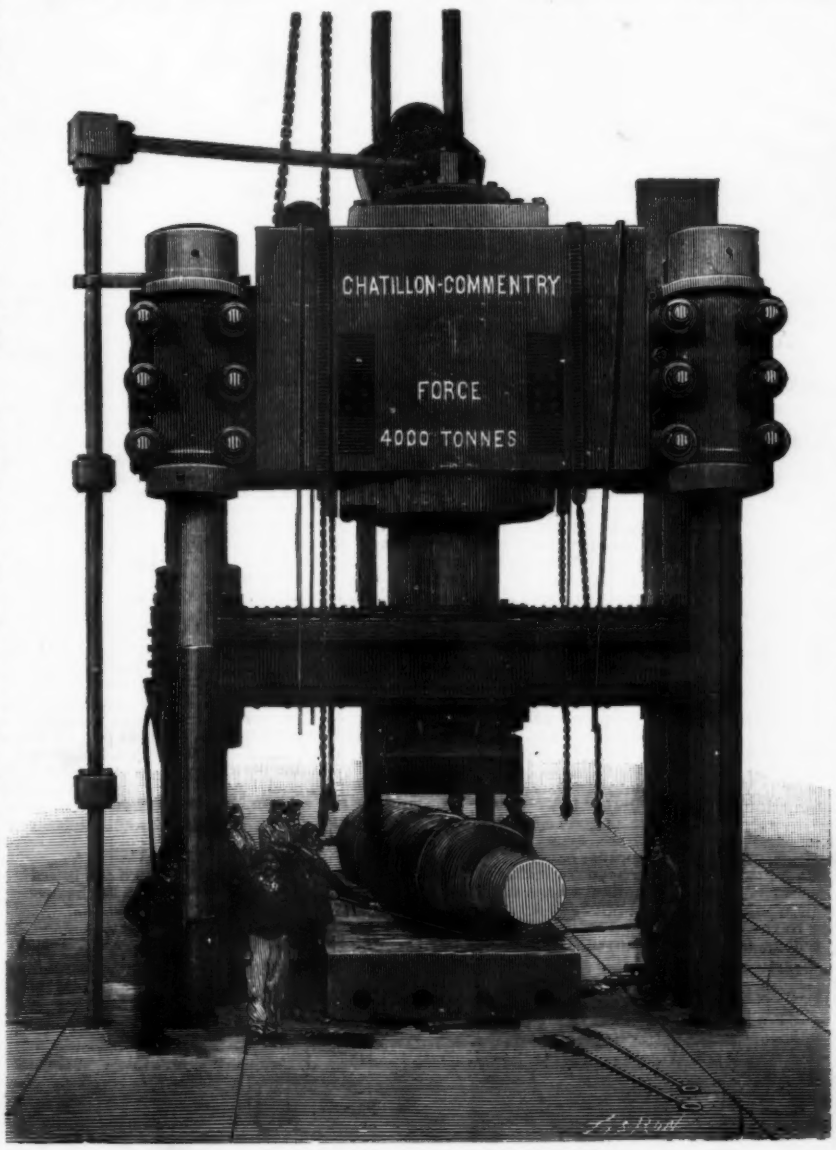
The apparatus consists essentially of two cross pieces connected by four strongly bolted steel columns, forming a structure that is absolutely invariable during the work. The upper cross piece is fixed, and carries in the center the high pressure cylinder that serves for forging. The lower cross piece is formed of girders firmly fixed in the earth, and on which the anvil bed may be shifted. It carries two low-pressure cylinders, which serve for raising the tool after it has ceased to operate.

The upper cross piece consists of two strong steel plates, 180 millimeters in thickness, strongly cross-braced, and connected by means of twelve bolts with the cast steel girders, in which slide the prolongations of the lifting pistons, as well as with the cross brace supports of the four columns.

The principal cylinder of the press, which is of forged steel, has an internal diameter of 1·1 meter. The thickness of the sides is about 300 millimeters. The cylinder is closed at the top by a threaded disk having an aperture in the center that permits of the entrance of water at a high pressure. Leakages are prevented at the joint through the interposition of a leather packing held in place by an iron disk and bolts.

The compressing cylinder is of cast iron. In the interior of it there is a cavity, in the bottom of which is fixed an iron core that transmits the pressure directly to the movable cross beam. The upper surface of the piston has a slightly convex form, which permits of its being raised to its full extent without causing any interruption in the work. The piston is provided at its upper part with a packing of hot-pressed leather, held between two steel rings.

The movable cross beam consists of a girder comprising two 25 millimeter thick steel plates 0·9 meter in height, connected by two webs 1·14 meter in width. This girder is 6 meters in length, and occupies the entire width of the press. It carries in the center the stamp holder, which presents a mortise in the form of a dovetail, in which may be assembled all the tools used in forging and shaping. At each of its extremities it allows of the passage, between its two sides, of the lifting pistons, which are firmly fixed to it by means of bolts and nuts.



A 4,000 TON FORGING PRESS.

The lower cross piece comprises: (1) In the transverse direction of the press, two strong steel plate girders, 1·7 meters in height, strengthened by angle irons embedded in the masonry and anchored deeply in the foundation by means of 65-millimeter bolts; and (2) in the longitudinal direction, two other girders of the same type, 0·9 meter in height, which rest upon the first and serve as supports and slides for the anvil bed. The latter is of cast iron and is in two parts, which are connected by keys. The anvils are fixed to it by means of three movable bolts.

The lower part of the anvil bed is provided in front with two lugs, with which are connected the two piston rods of the horizontal cast iron hydraulic cylinders fixed back of the press to the external sides of the second girders already mentioned. The horizontal displacement of the anvil bed obtained in this way greatly facilitates the changing of the anvils, as well as the handling of the pieces that it is desired to bring under the press; besides, it renders useless the complete lifting of the forging pistons for the placing of the templets upon the plates. The work of verification is always done outside of the press.

The lifting cylinders are connected by means of strong bolts with the cast iron cross-braced supports of the soft steel columns that serve to connect the two cross pieces, and are connected by bolts and nuts with the bottom of the large girders. They are of hematite iron, of the very best quality, and are bored out to a diameter of 530 millimeters throughout their entire length, to receive the forged soft steel piston already mentioned. These cylinders are in constant communication with the low-pressure accumulator, and send their water to it when the principal plunger descends. Stuffing boxes, lined with bronze, form a joint and prevent waste.

Let us finish this brief description of the press by saying that the stroke of the forging piston is about 2·44 meters, and that the spacing from axis to axis of the columns is 4·9 meters in one direction and 2·44 in the other. To the left of the press are arranged the apparatus for distributing water under a high pressure for the central cylinder, and water under a low pressure for the two horizontal cylinders which control the motion of the anvil bed. We shall describe only the first of these apparatus: It consists of a rectangular box of forged steel, containing two vertical compartments connected with each other beneath by a horizontal conduit, in which debouches a pipe that ends at the upper part of the compressing cylinder. The first communicates with the pipe that lets in the water under a high pressure, and the second with the return pipe. There are two valves that are actuated by a lever maneuvered at the level of the floor of the forge. The seats of these valves are placed in opposite directions, and their motion is so combined that when the first valve is lifted the other is hermetically closed, and *vice versa*, for, were it otherwise, the water might pass directly from the outgoing to the return conduit without acting upon the forging piston.

A second maneuvering lever, situated near the preceding, permits the engineer, who has already in hand the control of the forging, to change the flow of the water under low pressure, which goes to the horizontal cylinders, and, consequently, to effect the shifting of the anvil bed. These two motions are sometimes simultaneous, and it is essential to have them occur at the same point.

The installation of the piping for the transmission of the hydraulic power varies with the pressures in play. The pipes for the high pressure have to withstand 550 kilogrammes per square centimeter. They are of soft steel, 90 millimeters in internal diameter, and the thickness of the sides is 36 millimeters.

Blocks of forged steel serve for the junction of the various elements of this conduit. The low-pressure pipes have been so calculated as to be able to withstand a pressure of 55 kilogrammes per square centimeter. They are of iron, and have an internal diameter of 75 millimeters. The pipes that connect the low-pressure accumulator with the two horizontal double-acting cylinders resist the same charge of 55 kilogrammes, and have an internal diameter of 50 millimeters. Finally, another pipe starts from this latter system and ends at a small hydraulic motor, situated at the back of the forge room and designed to effect the maneuvering that determines the lifting of all the doors of the furnaces and the shifting of the movable dead plates of the furnaces for heating the large armor plates that it is desired to shape.—*Le Genie Civil.*

THE PORTLAND CEMENT TRADE OF THE WORLD.

MR. GIRON recently read before the Engineers' Club, at Philadelphia, a paper on the trade of the world in Portland cement, in the course of which he said that the present annual production in Europe amounts to over 20,000,000 barrels, and its commercial value to over $36,000,000. The first factory was established at Northfleet, on the Thames. The process was so crude that in 1850 only four factories were in operation. In England there are now over 8,300,000 barrels made each year. The process is much the same as it was twenty years ago. The raw materials are chalk and clay, both very pure, and although inferior processes are employed, they make a satisfactory cement. A few years ago the entire product of the kilns was put on the market, but the fineness of the Continental cements led English makers to improve their processes, although even now English cement is not, as a rule, as firm as Geneva or French Portland.

The manufacture was first introduced into Germany in 1852. Now there are sixty large works, having the same annual production as England. The raw materials are of exceedingly unfavorable character, but the manufacturers have made a serious study of the properties and uses of Portland cement, and now know exactly what rules to follow to regulate their operations, and the consumer can depend on the product offered him. The association of manufacturers has had much to do with the immense development of the industry in Germany.

In France the industry grew slowly, the total production in 1880 hardly exceeding 750,000 barrels a year; now it is 1,800,000 barrels. The works of the Company of French Cements, at Boulogne, form the largest Portland cement factory in the world, turning out about 800,000 barrels a year.

In Russia the first works were established in 1857, and there are now eight factories, producing 900,000 barrels a year.

In Belgium there are four works, producing 800,000 barrels.

In Italy the Portland cement industry does not really exist, although a certain kind of natural Portland is made.

In Denmark and Norway and Sweden there are ten factories, making about 800,000 barrels.

Portland cement was imported into the United States as early as 1868. In 1882 the amount imported was 370,406 barrels, and last year it exceeded 3,000,000 barrels. Little effort has been made to develop the manufacture here. The materials for manufacture are as difficult to handle as in Germany, and the processes are similar. The process requires about eight days, and demands great care to produce a uniform product. The cost of the system is too great to make it successful in America. The process used in the Portland Cement Works, at Coplay, in Pennsylvania, has entirely revolutionized the science of cement making. At that factory the raw compound is burnt in a powdered condition while traveling in an inclined rotary furnace in an intensely hot petroleum flame, and a few hours is sufficient to finish the process. The cement is guaranteed to stand 400 lb. in seven days, 500 lb. in a month, and 600 lb. in three months, and to leave no more than ten per cent. residue on a No. 80 sieve.

APPARATUS FOR LIFTING BLOCKS OF BETON.

MESSRS. J. & C. BARATOUX, contractors, ha e, since 1882, been employing a hand power machine for lifting blocks of beton in the work on the port of Boulogne-sur-Mer. The machine is drawn by horses

Two lateral frames, A A, composed of iron plates and angle irons, and connected with each other by three strong crosspieces, B B, constitute the framework of the apparatus. To the soles, C C, are fixed three pairs of wheels, which roll upon a track of three meters gauge. A windless, E, fixed to the crosspieces and actuated by hand, raises and lowers the beam, F, through the intermedium of the transmission, *a* .... *b*. Two platforms, H H, permit two men to stand at the level of the winches, *a a*, and easily effect the maneuver of lifting. Hooks, I I, at the extremities of the soles permit of hitching the horses to the machine.

The block, having been lifted a few centimeters, is drawn by two horses to a car situated upon the shipping track, to be carried thence either to the embarkation crane or to the block-carrying trucks for immersion by land. This shipping track, which constitutes the main artery of the works, is placed at the extremity of the platform upon which the blocks are manufactured and below the longitudinal tracks.—*Revue Generale de Mecanique Appliquée.*

A POND DREDGER.

THOSE concerned in the removal of mud and refuse from ponds, canals, or other stretches of water, will be interested, says *Industries*, in a mechanical appliance—which may be called a pond cleaner or mud scoop—belonging to the Southwestern Counties Steam Cultivating Company, which has recently been tested in a pond in Froyle Park, Alton, Hampshire.

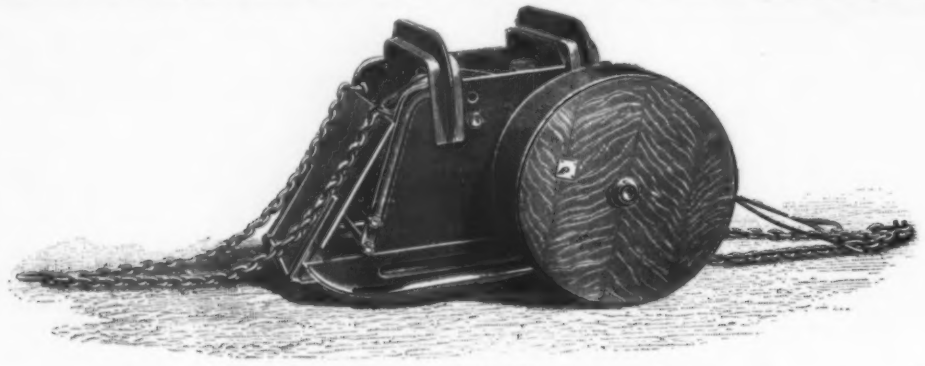


FIG. 1.—CLOSED.

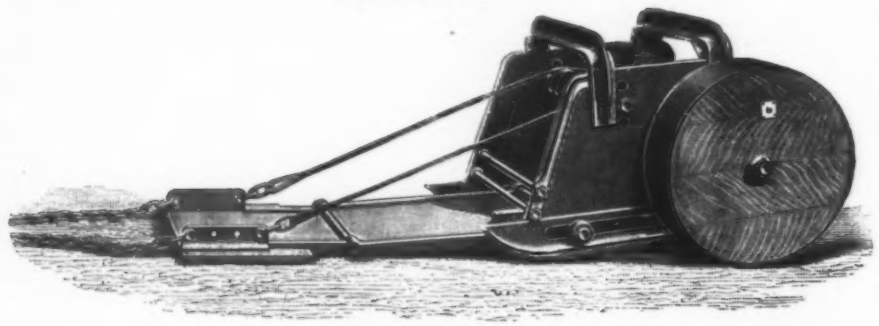


FIG. 2.—OPEN.

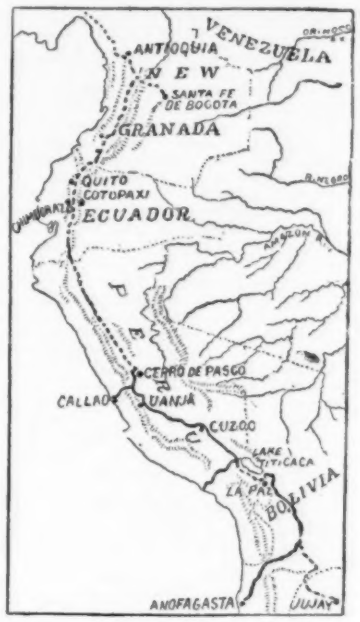
A POND DREDGER.

This machine, which is illustrated herewith, was invented by Mr. J. E. Brown, the manager of the company, and consists of a box-shaped receiver mounted on broad hollow wheels in such a manner as to allow the bottom of the machine to slide upon the ground. The end and bottom of the dredger are movable, so that when it is being hauled back the gearing allows the end to fall upon the ground. Thus, no opposition being offered to the return of the machine to the opposite bank of a pond, the mud is allowed to pass freely through it. On arriving at this bank, however, the rope being tightened by a suitable hauling engine, the bottom is slid back into its place, and the open end, which was lying flat, is pulled to a vertical position, thus preventing the passage of the mud, and causing the machine to act as a scoop, which is then dragged through the pond by the hauling engine. The scoop recently tested is capable of thus bringing upward of a ton of sludge to the bank every journey.

As each trip across the pond in Froyle Park only occupied about one minute, it will be seen that a large amount of material can be removed by this appliance in an hour. The use of the sliding bottom is intended to allow of the dredger being easily emptied when brought up on the bank. Two 12 horse power engines—one at either side of the pond—were employed for hauling purposes, and in the space of thirty hours, we are informed, the pond had been cleared of about 2,500 tons of refuse. Messrs. John Fowler & Co., engineers, of Leeds, have arranged for the manufacture of this dredger.

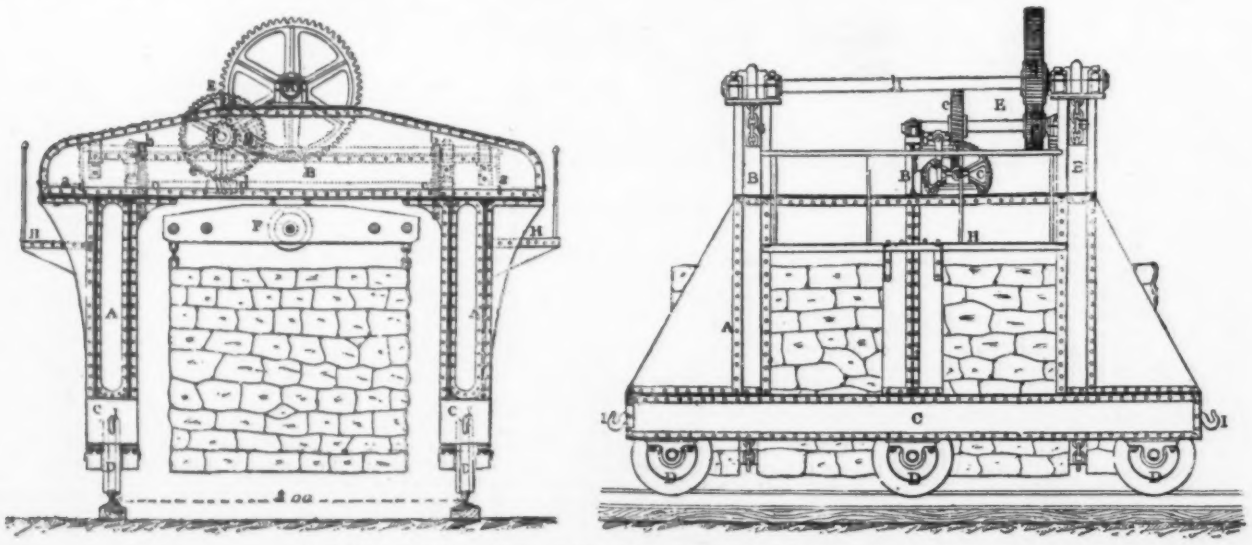
THE RAILWAY BETWEEN THE UNITED STATES AND SOUTH AMERICA.*

As the Intercontinental Railway surveys progress, the supposed difficulties become myths. South American geography is found to be as much at fault as that of the North American continent was two generations ago. The great American desert narrowed and contracted until it disappeared from the maps. So, too, the ruggedness of the Andes has proved to be in a large degree imaginary. When the idea of a three-Americas railway was broached, it was thought that there was a choice of only two routes from the Isthmus down through South America. The road must follow the Pacific coast line west of the Andes, or it must go along the foothills of the Andes on the eastern slope, crossing the head waters of the Amazon and other rivers flowing eastward to the Atlantic. But it now develops from the surveys that neither of these will be the Intercontinental route. Leaving Central America and the Isthmus, the iron horse, headed south, will work his way upward through the knot of the Andes at the head of South America. By some tunneling and twisting he will get into the Cauca Valley and follow that to its head near Popayan. Thence southward for many hundreds of miles the route is upon a high, wide plateau, between ranges of the Andes. There are mountains to the right and mountains to the left, just as one sees in riding southward from El Paso to the city of Mexico for three days. But between the ranges is this high plateau, presenting a natural route for railroad building. In fact, then, the route through South America is down the backbone of the continent. It is a broad and comparatively level backbone when one has climbed to the level several thousand feet above the sea.



At the northern Colombian line the South American section of the Intercontinental begins. Southward through the knot of the Andes, into and up the Cauca Valley to Popayan, and along the high plateau between ranges of the Andes to Quito, in Ecuador, is a distance of 900 miles. That, when the work of survey was undertaken, was regarded as the most problematical part of the great undertaking. Engineering corps No. 2 started at Quito, the southern end of this middle section. According to the latest reports received by the commission, the corps has passed Popayan and is now coming northward down the Cauca Valley. The general tenor of the reports is that the difficulties encountered are nothing like what were feared. The Cauca Valley is said to be almost another paradise. To get into it from the northward the road must be built through some very mountainous country between

* For an interesting and valuable paper on Peru, its commerce and resources, see SUPPLEMENT, 853.



APPARATUS FOR LIFTING BLOCKS OF BETON.

Antioquia and the north line of Colombia. That part of the route is yet to be surveyed. Antioquia is now one of the most important cities of the northern part of South America. With the building of the Intercontinental railway its importance will be vastly increased. From or near Antioquia two branches will leave the main stem. One of these will run northward down to the coast of Cartagena. The other will extend almost due east into the heart of Venezuela and down to the port of Cabello. From Antioquia up the Cauca Valley the main line is by way of Neira, Monizales, Cartajo, Buga, Palmira, and other cities to Popayan. Rich mining regions lie tributary to several of the places mentioned. Before Popayan is reached another branch leaves the main stem, extending eastward through the Andes to Bogota, the capital of Colombia. This opens up the famous Magdalena Valley to the railway.

South of Popayan the road must cross some mountains to reach Pasto. That is one of the worst places on the route, but the engineers have passed through it and found it practicable. From Pasto the way is comparatively easy by Ipiales or Tulcan into Ecuador, and thence to Quito. The Quito Valley is the best part of Ecuador. It is the most populous part of that country.

Engineering corps No. 3 began at Quito and proceeded southward. So light was the work found to be from the head of the Perene River, near Janja, to its junction with the Apurimac. From that point to Santa Ana there is a line to be surveyed, and from Santa Ana to Cuzco local enterprise is already in the field. South of Cuzco a railroad eighty miles long to Santa Rosa is under contract and to be finished in two years. From Santa Rosa there is a railroad completed southward to Puno, on Lake Titicaca, and thence westward to Mollendo, on the Pacific coast. The section from Santa Rosa to Puno is just in line for the Intercontinental from Puno. From Puno the route will skirt Lake Titicaca to the Bolivian border, and thence to La Paz. Across Lake Titicaca from Puna to La Paz there is water communication. The distance is only forty-five miles. It will be more around by land.

From La Paz the intercontinental route bears off to the southeast, and the next important point is Oruro. At Oruro the Bolivian railroad system is reached. A railroad is built from Oruro southward to Huanchaca. It has just received its finishing touches, and, according to the latest information received by the Intercontinental Commission, was to be opened on the 16th of this month. This link in the Intercontinental from Oruro to Huanchaca is of the system beginning at the Chilian port of Autofagasta, on the Pacific coast, and now extending inland 300 miles. The Intercontinental will bisect this system, and Huanchaca will be a great

RAILWAY MAP OF PERU AND BOLIVIA.

that the party, as shown by the latest reports, has now traversed the whole distance assigned it from Quito southward to Cerro de Pasco, 800 miles. From Quito southward the route is by way of the cities of Ambato, Riobamba, Cuenca, and Loja. Then Peru is entered. The route through Peru is by way of the Maxanon Valley to Cerro de Pasco.

The work of the Intercontinental Railway Commission, so far as surveys are considered, practically ends at Cerro de Pasco. There the region in which South American enterprise is already actively at work is reached. True, it is a long gap south of Cerro de Pasco to Jujuy, the northernmost terminus of the Argentine system, but much of it has been surveyed by local companies, and several projects are under way. Railway construction is going on so rapidly in South America that the people of the United States have little comprehension of it. The first instructions only took engineering corps No. 3 as far south as Cerro de Pasco. Supplementary directions have been given by which the corps is continuing southward as far as Cuzco. South of Cerro de Pasco a short distance the corps will strike the Peruvian system of railways at Janja. From Janja a railroad is now in operation westward by way of Lima to Callao, on the Pacific. From Janja to Cerro de Pasco is 100 miles, and the railroad to cover it is now under contract. So here is a South American gap in the Intercontinental now being constructed.

From Janja southward to Cuzco, the ancient capital of Peru, is 250 miles. But a railroad is being built which will fill another gap. This section of road is central distributing point. Here the eastward branch will start for Rio Janeiro. Southward a road is already surveyed and projected to Jujuy, where connection is made with the entire Argentine system, the most extensive railway system in South America. Jujuy is not so dangerous as it looks. "Hoo-wee" is the way it goes. From Jujuy to Buenos Ayres, 993 miles, the Intercontinental is ready for through cars.

There is really a good deal more railroad than 2,500 miles to be actually constructed before the all-rail connection is made between New York and Buenos Ayres, but local necessities and local enterprise are supplying many links, and doing it rapidly. Therefore, the Intercontinental Railway Commission only feels called upon to demonstrate the practicability of the enterprise for gaps aggregating 2,500 miles. The Intercontinental Railway is feasible from an engineering point of view. Will it pay? On this point the commission is gathering the latest figures as to population and trade in the countries which will be traversed. Below is given in concise form the data as to Central America placed before the commission at the recent meeting.

Mexico has an area of 751,500 square miles and a population of 12,000,000 people. The principal articles imported to the United States from Mexico are in the order named: Flax and other fibrous substances, silver ores, coffee, hides and skins, chemicals and drugs, woods, and other articles of minor importance. The exports of the United States to Mexico are: Iron and steel manufactures, vehicles, furniture of all kinds, cotton goods, drugs and medicines, glass and earthenware, stationery, provisions, quicksilver, leather goods, etc. Last year the United States took from Mexico $41,593,423 worth of her products, and sold her $15,197,354. This was an increase of $10,000,000 on imports in four years, and of nearly $6,000,000 exports in the same period.

Guatemala comes next, with a population of 1,225,000 and an area of 46,800 square miles. Coffee, cocoa, hides, and woods are the main products. The coffee crop of last year was 80,000,000 pounds, and the cultivation is increasing steadily every year. The foreign trade of Guatemala increased from $9,781,339 in 1888 to $16,052,140 last year. The principal imports of Guatemala are silk, cotton, linen, and woolen goods, railroad and agricultural materials, hardware, iron, wine, leather goods. Last year Guatemala sold to the United States $3,889,181 worth of her products, and bought of us $2,220,094. Our exports to Guatemala have doubled since 1889. A large part of the trade between the United States and Guatemala now goes by way of San Francisco.

Salvador has 7,300 square miles and a population estimated at 665,000. It is small, but in proportion to its size is the most populous and prosperous republic of Central America. Coffee is the principal product. Indigo, sugar, and medicinal plants and woods grow abundantly. Salvador is especially rich in gold, silver, iron, copper, and mercury, and now has 200 mines in operation. The exports far exceed the imports, and that accounts for Salvador's prosperity. The United States bought last year from Salvador $1,850,432 worth of her products and sold to her $1,235,723. The total foreign trade of Salvador was about $6,000,000. It is notable that the United States has just doubled her exports to Salvador since 1888, and that by steady increase each year. This trade goes by way of Pacific ports.

Honduras is second in size of the Central American republics, with an area of 46,400 square miles and a population of 440,000, principally Indians. The soil is fertile and the conditions so favorable that Honduras raises a greater variety of products than almost any other country. The mineral resources are enormous, but are not fully developed, owing to a lack of capital and labor and the absence of adequate means of transportation. The exports are chiefly cattle, mahogany, cedar, hides, India rubber, bananas, cocoanuts, bar silver, and gold bullion. The imports comprise cotton goods, silks, hardware. This country last year bought from Honduras $1,287,558 worth of her products and sold her $682,886 worth of ours. The entire foreign trade of Honduras is something of a mystery, because of the practice in that country of farming out to individuals the collection of customs at various ports. It is to the interest of these parties to conceal the amount of trade.

Nicaragua has 49,500 square miles and 350,000 people. The resources are great, especially in fine hard words, dye woods, rubber, and other plants. Sugar, coffee, and indigo are largely cultivated. Maize and potatoes grow abundantly in the highlands. Nicaragua is especially well adapted for live stock, and on the eastern shore of her great lake thousands of cattle are raised. Gold has been discovered recently. The trade of Nicaragua with the United States exceeds that with any other country. Coffee, crude rubber, bananas, hides, and skins are sent to the United States, and machinery, iron, steel, wheat, flour, provisions, and manufactured goods are sent back. Last year Nicaragua's exports to the United States were $1,823,583, and her imports from the United States were $1,730,477.

Costa Rica's name indicates her richness. Everything will grow within her 23,233 square miles of territory. The favored people number 214,000. Costa Rica is the great banana country. The cultivation of the banana has increased greatly to meet the demand from the United States. Wheat and other grains are produced. The forests abound in valuable timber. Rare woods for cabinet work and medicinal and oleaginous plants are found, as well as rubber textile plants and dye woods. Costa Rica, according to the latest statistics, has 250,000 head of cattle, 50,000 horses, and other animals. She is also rich in gold, silver, coffee, zinc, nickel, iron, lead, and coal. Manufacturing has made some headway. There are breweries, iron and tool foundries, and a distillery in Costa Rica. The principal articles that country buys are silk, woolen, linen and cotton goods, toilet articles, wines, liquors, flour, refined sugar, wearing apparel, and leather goods. The total foreign commerce of that country amounted last year to nearly $13,000,000. The United States has recently superseded England in the commercial good graces of Costa Rica. Last year the United States sold to Costa Rica more than one-fourth of her total imports, and took from her 40,000 tons of bananas, 45,000 sacks of coffee, and altogether nearly $3,000,000 worth of goods and bullion.—*Globe-Democrat.*

THE GOVERNMENT SYSTEM OF RAILWAYS IN SUMATRA.

THE *Revue Générale des Chemins de Fer* has recently published a careful study by Mr. Post, a celebrated Dutch engineer, on the new government system of railways in the island of Sumatra. This system, which is not yet entirely finished, and the length of which will reach 106 miles, does a large freight business, for it serves for the exportation of indigenous products, such as coffee and rice, and the carriage of coal taken from the beds situated near Lake Singkarah. Later on, it will permit of the importation of petroleum to the interior of the island. What makes it of peculiar interest from the standpoint of the railway engineer is that it comprises sections having steep gradients provided with racks, which are traversed by ordinary trains under the same conditions as the sections traversed by simple adhesion. This is the first time, we believe, that rack lines have been interposed in so important a system, and we have thought it would be of interest to give a few details on the subject derived from Mr. Post's article. We shall add thereto certain data that Mr. Riggenbach has been so kind as to communicate to us. The coal beds for which service is to be done are situated to the east of Lake Singkarah, in the narrow valley of Lounto. Their extent is very great, for the deposit amounts to 13,250,000,000 cubic feet, according to Mr. De Greve's estimate. Starting at Lounto at an altitude of about 820 ft., the railway as-

cends the valley over gradients of $\frac{1}{4}$ of an inch per foot at a maximum and curves of 490 ft. radius at a minimum up to a tunnel 2,700 ft. in length. It afterward enters the valley of the Lassi, which it ascends with gradients of $\frac{1}{10}$ in. to the foot as far as to the secondary summit of Solok, at an altitude of 1,360 ft. The line afterward follows the border of the lake with mean gradients of $\frac{1}{16}$ of an inch, avoiding as far as possible the cones due to the erosion of the rocks that are met with in great numbers in the plain. From Baton-Tabol to Padang-Pandjang, the land has such a slope that it would have been necessary to give an excessive length to a simple adhesion line, and it was therefore decided after a careful study to admit a gradient of $\frac{1}{2}$ of an inch, and provide it with a rack.

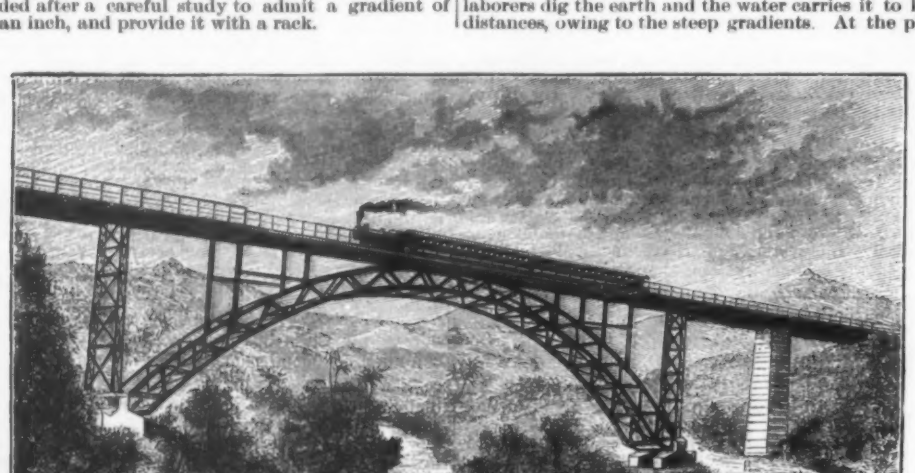


FIG. 1.—RAILWAYS IN SUMATRA.

It must be observed, however, that this solution of the question, which has permitted of considerably diminishing the cost of the first establishment, did not, so to speak, introduce any difficulty in the way of the exploitation, for the mixed locomotives employed are capable of hauling over this $\frac{1}{2}$ of an inch gradient provided with a rack the same load as upon the $\frac{1}{100}$ inch gradient admitted for the ordinary road. It will be at once seen that the speed of running of the parts is diminished in a ratio inverse to the stresses thus developed.

At Padang-Pandjang, situated at an altitude of 2,530 ft., there starts a branch that runs to Fort de Kock. This military center is the principal garrison place of the Dutch troops of occupation. The direction line ascends to an altitude of 3,785 ft. above the level of the sea and crosses at Kota-barou the neck that separates the formidable volcano of Merapi, Moro-Api, or "Destroying Fire," from that of Singalang. Thence it descends to the fort, situated at an altitude of 3,017 ft. This section presents gradients reaching one inch to the foot, and is provided almost wholly with racks.

As far as to Padang-Pandjang, the line runs over the high, populous and healthful plateau of Menang-Kabreo, which is in a measure the *sanatorium* of convalescent officers and functionaries. Mr. Post observes that these very rich districts have a population as dense as that of the most populous countries of Europe. Padang-Pandjang, which is the residence of the functionaries and the chief place of the "Quatre Kota," occupies the edge of this plateau.

On leaving this city, the line descends the side of the plateau by an abrupt gradient extending as far as to Kaiou-tanam, and afterward runs toward the port of Padang upon the ocean, one of the busiest markets of Sumatra. The section from Padang-Pandjang to Kaiou-tanam is almost entirely provided with racks with gradients of $\frac{2}{3}$ of an inch to the foot. On the ordinary road the gradient reaches $\frac{1}{33}$ of an inch. Beyond Kaiou-tanam the line has no racks. The gradient is limited to $\frac{1}{16}$ of an inch to the foot in going toward Padang, but it reaches $\frac{1}{18}$ and $\frac{1}{16}$ in the opposite direction. On reaching Padang the line bifurcates, one branch running toward Poulon-Ayer and the other toward Port Emma, which is the terminus. But these two points must be considered rather as dependencies of Padang, which, outside of the central quarter, presents the aspect of a large park, with its isolated houses surrounded by gardens and extending over a wide area.

The establishment of the substructure of this important 106 mile line necessitated the formation of much earthwork, upon which we shall not dwell, but shall merely mention the curious application made of the property possessed by running water of carrying along earth and depositing it at the place where the velocity of the current diminishes.

The water is led, says Mr. Post, by small canals whose length sometimes reaches several miles. The laborers dig the earth and the water carries it to long distances, owing to the steep gradients. At the place where it is desired to establish the embankments, barriers of bamboo are set up which allow the water and mud to pass, while the solid earth, gravel and sand deposit. These embankments, which are so to speak washed, are very solid, and it is possible even during the execution of the work to traverse them on foot and horseback. The loss of material reaches 25 or 30 per cent.

The line includes, besides, a large number of bridges and culverts, and especially iron plate aqueducts or cast iron siphons, the installation of which became necessary in order that the rice fields traversed should not be disturbed.

Among the metallic bridges we represent in Fig. 1 the viaduct that crosses the river Anei at its confluence with the Ponti between Pandjang and Kaiou-tanam. This viaduct, which is located in a most picturesque situation, presents a very beautiful aspect, as may be judged from the figure. It is on a gradient of $\frac{5}{10}$ of an inch, and carries a rack. In order to ease the bridge, the rack is made fast to the extreme piers, which thus receive the lateral thrust transmitted by the reaction of the toothed wheel of the locomotive; the bridge, on the contrary, supports only the vertical weight. In order to resist this longitudinal stress, the uprights are arranged at right angles with the track, and consequently present an inclination upon the vertical.

As regards the superstructure, we may mention in particular the metallic ties, the use of which is necessary in hot countries, since wood there rots too rapidly.

The ties have a variable profile, calculated according to the theoretical stress, supported at each point. This type, which is well known and justly appreciated, is due to Mr. Post. It has received numerous applications in Europe, and it is under trial in France, too, upon certain sections of the government railways.

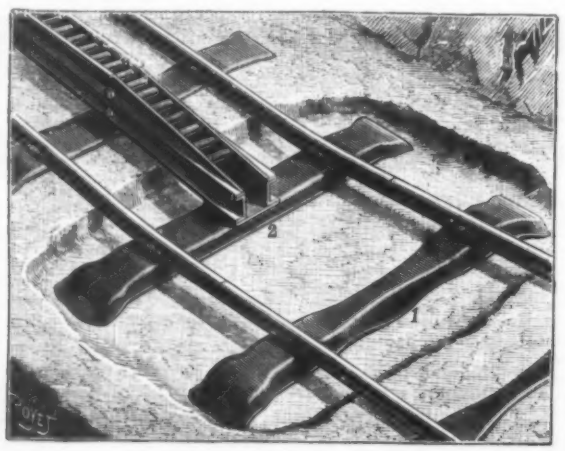


FIG. 2.

Fig. 2 shows two types of ties employed. Those of the ordinary track are contracted in the center (No. 1); Those of the rack sections, on the contrary, have parallel sides, and are provided in the center with two holes, that serve for fixing the rack (No. 2). The ties weigh 85 lb. each, and the ordinary track weighs 75 lb. to the running foot.

The Riggenbach rack consists, as well known, of a sort of metallic ladder, the rounds of which are riveted to two vertical U-shaped uprights fixed upon the ties. At the entrance of the sections provided with a rack, the latter presents a beveled, movable part resting upon a spring, which gradually yields under the action of the toothed wheel of the locomotive in order to facilitate the gearing.

Traction is effected by means of two types of locomotives, one consisting of simple adhesion engines, with two coupled axles, which are capable of running only upon the plain sections, and the total weight of which in service reaches about 26 tons, and the other comprising mixed engines of a total weight of 26 tons, capable of running both upon the plain and rack sections. These latter engines have three coupled axles, and an axle in front capable of a certain displacement on account of curves. Two of the axles are provided with simple adhesion wheels and the third carries the toothed wheel. In the arrangements of the most recent mixed engines, we meet, on the contrary, with two mechanisms and even two pairs of entirely independent driving cylinders; but in Sumatra, where engineers of but little experience are available, the simplest arrangements have rightly been preferred.

The engine is provided with three types of brakes—spring brake, air brake, and an auxiliary toothed wheel, which is capable of arresting the mechanism. The locomotive is always coupled to the rear of the train, which it pushes during ascents and holds back during descents. The cars are of the American type, and are arranged for two classes of travelers. The freight cars are each capable of carrying 20 tons of coal.

The work of constructing the line is done in great part by Chinese laborers and also by transported criminals, and Mr. Post points out that, owing to the vigilance, tact, and courage of the engineers and overseers, a regular and satisfactory work is got out of these prisoners.

The section from Poulon-Ayer to Padang-Pandjang was delivered up for exploitation on the first of last July, and the line must now reach the station of Fort de Kock.

The results of the exploitation are very satisfactory for so short a time. The aborigines themselves, says Mr. Post, have not shown that hesitation to travel by *carreta api*, "fire cars," that it was feared they would.

An ornamental time table, in colors, bearing inscriptions in Dutch, Malay, Japanese, and Chinese, gives the hours at which the trains arrive and depart, the height and temperature of the principal health stations, and exhibits in pretty landscapes the country traversed and its products, etc.—*La Nature.*

[FROM ENGINEERING.]

A SHORT HISTORY OF BRIDGE BUILDING.*

By C. R. MANNERS.

IN America iron was used to a small extent as far back as 1835, but its use is now general. Accustomed to trussed timber bridges, they naturally employed iron in that form also. In one common form a cast iron cylindrical pipe is used for the compression member. In 1848 the Whipple truss (Fig. 81) was introduced.

A truss now in very general use is, I think, that designed by Mr. Albert Fink, of which I give an example (Fig. 82).

The top member and the vertical struts are cast iron pipes, octagonal in external form, the top being about 12 in. in diameter externally and the struts about 8 in. in diameter. The tension bars are of wrought iron 4½ in. by 1¼ in. The Americans would appear to have been rather too saving of material in the construction of their bridges, as Mr. C. F. Stowell, bridge engineer of the New York State Railway Commission, states that during the ten years ending December 31, 1887, no fewer than 251 railroad bridges failed in the United States and Canada, from weakness, overwork, collision, etc. This number embraces truss bridges only, and includes only those which involve the wreck of the whole or part of a train. A gradual preference is, however, now being shown for the plate girder in place of the truss. In the ordinary plate girder we seem to have reached the limits of simplicity. What could be more simple than a top and bottom plate united by a vertical web plate?

When, however, the great development of the railway systems necessitated larger spans, this form of girder was found liable to distortion through twisting, expansion, etc., and in designing the Britannia Tubular Bridge over the Menai Straits, Mr. Robert Stephenson had not only to face the difficulty of arranging his material to resist a transverse strain, but also the difficulty of obtaining suitable material, and of devising a beam sufficiently strong and rigid to maintain its form during construction as well as when in place. A tubular girder is very much like two simple plate girders side by side, with their top and bottom flanges united.

The Britannia Bridge (Fig. 83) consists of two independent and continuous wrought iron tubular beams each 1,511 ft. long and weighing 4,680 tons each. They are 15 ft. wide and 23 ft. deep at the ends and 30 ft. deep at the center. There are two spans of about 460 ft. and two of 230 ft., resting on piers 100 ft. above high water. The tubes were built at some distance from the site of the work, then floated on pontoons to the base of the towers and hauled up by four chains by hydraulic pressure.

The bridge was opened in 1850, and cost 601,865*l.* This and the Conway Tubular Bridge were the first great examples of properly designed wrought iron girders. The Victoria Bridge over the St. Lawrence, 7,000 ft. long, is another good example of this construction.

The solid or continuous vertical plate of the wrought iron girder soon led to the introduction of the lattice or trellis girder, in which the vertical plate is superseded by a series of diagonal bars, of one or more systems, crossing each other and forming a more or less open trellis work with, at regular intervals, vertical stiffening pieces introduced. The simplest form of this girder is that known as the Warren girder, which has a single system of diagonals.

The Newark Dyke Bridge (Fig. 84) is one of the earliest and I believe is still one of the largest constructed on this system. It was erected in 1852 from designs by Mr. Charles Wild.

* Continued from SUPPLEMENT, No. 854, page 13644.

The span is 359 ft., and the depth 16 ft. It consists of four independent girders, two for each line of rails. The top member is a series of cast iron pipes, butting end to end and bolted together, and is 18 in. in diameter at the center, tapering off to 13¼ in. at the ends. The bottom member is of wrought iron links 9 in. deep and ⅞ in. thick. There are fourteen of these links at the center, the number diminishing toward each end. The tension bars are of wrought iron, and the struts of cast iron. The bearings at the ends are strong cast iron triangular frames.

One of the finest examples of Warren girder is the great Crumlin viaduct by Mr. T. W. Kennard. The length is 1,500 ft., and the height of the viaduct is 200 ft. The piers are clusters of cast iron columns braced together. Each span of 150 ft. has four girders about 15 ft. 6 in. deep. The bridge was opened in 1857 and cost 62,000*l.* (Fig. 85.)

In Germany the general construction for large span bridges is the lattice, in some one of its various forms, and in fact the lattice system was introduced into this

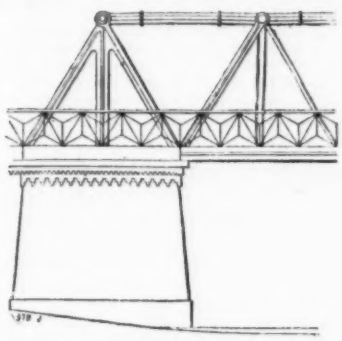


FIG. 84.—NEWARK DYKE BRIDGE.

country from Germany by Sir John Macneil. There is a large bridge over the Vistula of six spans, each 397 ft. 6 in., the depth of the girders being 38 ft. 9 in. The webs are lattice work of two rows, crossing each other at right angles. I may here mention that the method of sinking iron cylinders for piers, by means of compressed air, was invented in 1841 by Mr. Triger, and was first used on a large scale by Mr. Hughes, at Rochester.

At a comparatively early date in the history of iron bridge building it was proposed by a Mr. Pope to construct bridges to 1,000 ft. span on what he claimed as a new principle and called the "flying lever pendent bridge." They were to consist of a combination of struts and ties, so arranged that one-half of the bridge was a huge cantilever and the abutments were to act as a counterpoise. They were to be built prognosively from the abutments toward the center, and without centering or scaffolding, and in either wood or iron. It was, however, reserved for Sir John Fowler and Sir Benjamin Baker to show what could actually be done by the application of the cantilever and continuous girder system in the great Forth Bridge just completed and so fully described in the engineering journals that any lengthy description would be superfluous. The original design for this bridge, by Messrs. Fowler & Baker, was approved of in 1881, and in the following year an act of Parliament was obtained for its construction. In December of the same year contracts were entered into with Messrs. Tancred, Arrol & Co. The length of the cantilever arms, six in all, is 680 ft., and the two central connecting girders are each 350 ft. The two main openings have each a span of 1,710 ft. from center to center of the vertical columns, or 1,912 ft. 6 in. from center to center of the towers. The length of the cantilever bridge is 5,330 ft., and the total length of the bridge is 8,295 ft. 9 in. The rail level is 157 ft. above high water and the height of the towers, from center of bottom member to center of top member, is 330 ft.

(To be continued.)

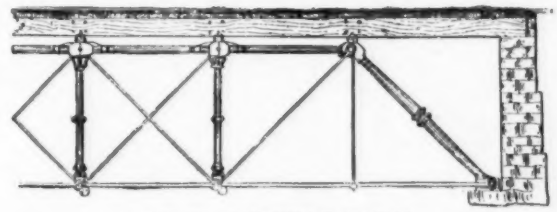


FIG. 81.—WHIPPLE TRUSS.

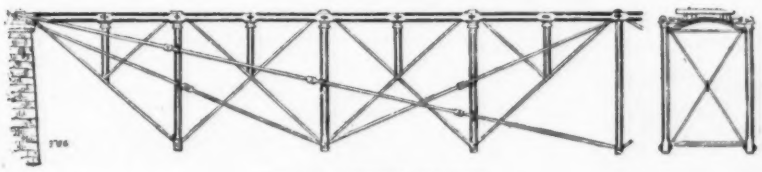


FIG. 82.—FINK TRUSS.

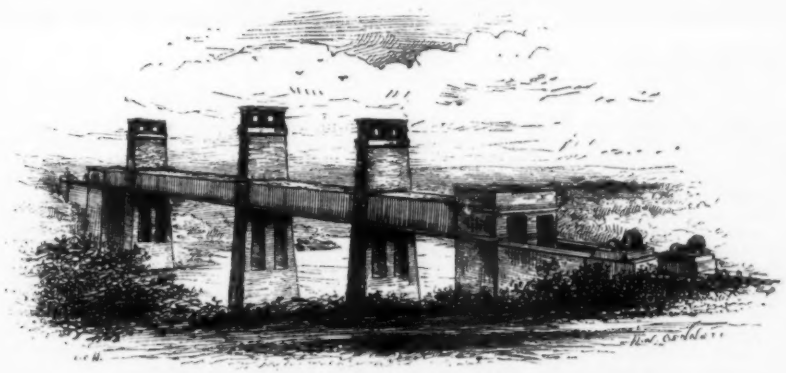


FIG. 83.—THE BRITANNIA TUBULAR BRIDGE.

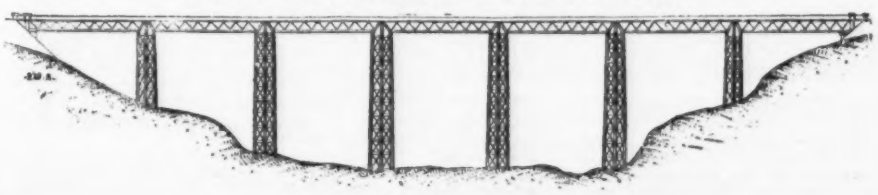


FIG. 85.—CRUMLIN VIADUCT.

A NEW SUCTION PUMP.

WE illustrate herewith an apparatus which was operated at the last Exposition of Work as a lift pump, and which has the merit of completely suppressing

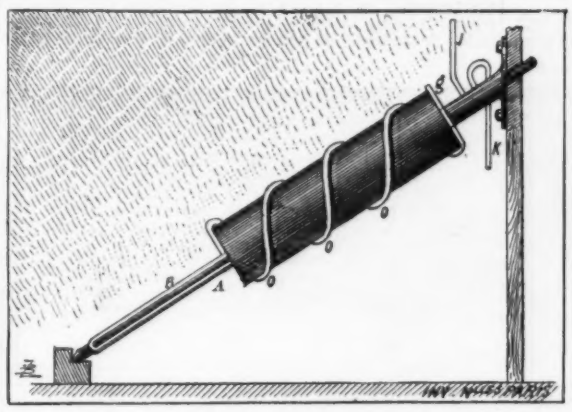


FIG. 1.—NEW SUCTION PUMP (FIRST MODEL).

clack valves, which always constitute the weak elements of a pump, whatever be the care taken in setting them.

In order to well understand the mode of operation, it suffices to take a glance at Fig. 1, which shows the first model of the apparatus, and which had the sole inconvenience of being somewhat cumbersome. It consists of a glass or wooden cylinder surrounded with a spiral tube, O, which makes about three revolutions, the end of the last spiral dividing into two branches, B and C. The tube, B, descends to the pivot of the apparatus, returns along the axis, and communicates with the first spiral at the point, G. The tube, C, traverses the cylinder, passes above the apparatus, and ends like the other at the first spiral at the point, G.

A quantity of mercury sufficient to fill half of the spirals is introduced through the orifice, M, which is then closed. If the tube, K, be then put in communication with the liquid to be raised, and the apparatus be given a rotary motion, the water will be observed to rise and gradually fill the remaining portion of the tubes. Starting from this moment, the first spiral, at every revolution of the cylinder, empties its contents into the second, and this into the third, and the latter empties the mercury and the water that it contains into the tubes, B and C. Then the water is forced again into the tube, C, and makes its exit from the extremity of the tube, K, while the mercury, through

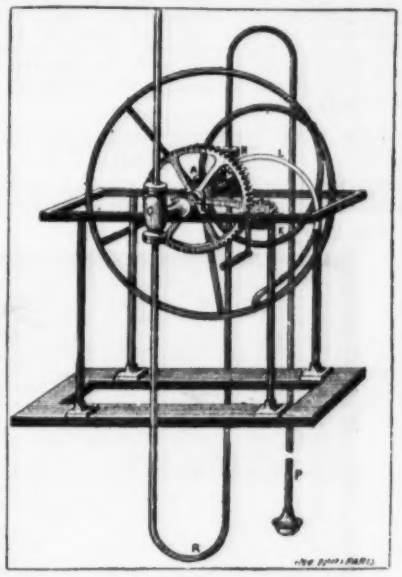


FIG. 2.—IMPROVED MODEL.

the effect of its weight, falls back into the tube, B, to recommence the same motion indefinitely.

It will be seen that it is possible at every revolution to lift a volume of water equal to half the volume of the spirals, and to a height dependent upon the diameter of the spirals and the number thereof.

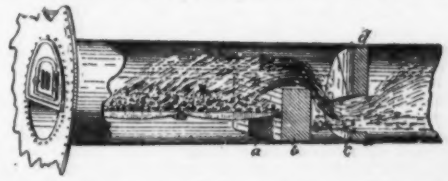
It will be conceived that the operation would be identical if the tube, K, were put in communication with a closed vessel in which it was proposed to create a vacuum. Every revolution of the cylinder would expel a quantity of air equal to half the volume of the spirals and to the pressure existing in the vessel.

As we have before said, this apparatus is somewhat unwieldy, and so the inventor has very happily modified it by replacing the tube spirally wound upon a cylinder by a simple tube, I J K L, forming a spiral of 1·2 meters, whose branches are in very approximate planes, and mounted upon an iron axis which revolves upon two journals, with tight joint. Two cast iron boxes, G and H, put the spiral in communication with the rest of the apparatus. These boxes are connected with a return tube about one meter in length. In order to prime the pump, a quantity of mercury sufficient to fill this tube and a third of the spiral is introduced through the box, G. A rotary motion is given the latter by means of the wheel, A, actuated by a pinion set in motion by means of a winch. At the end of two or three days the pump will be primed.

We shall not dwell upon the operation of the pump, as that is the same as in the primitive apparatus. We think that what has been said will suffice to show the ingenuity of this apparatus, which will probably find numerous applications in laboratories and the industries.—*Les Inventions Nouvelles.*

IMPROVED SMOKE ANNIHILATOR.

THE principle followed by Mr. Thwaite, in his appliance for the prevention of smoke in steam generators, consists, says the *Engineer*, in the admission of a secondary air supply through a wire gauze of a specific mesh, adapted to offer the requisite frictional resistance to the passage of such air, so as to accord accurately with the "pull" on the grate which remains unaffected. The form in which this invention has hitherto been applied by the Gaseous and Liquid Fuel Supply Company, of Manchester, who have acquired Mr. Thwaite's patent, has been in that of a box or casing of iron fitted with the necessary gauze, which is built in the bridge below the firebars, but so that it can be withdrawn and replaced at pleasure for the purpose of cleaning. Furthermore, a drop arch was provided, which, becoming incandescent, assisted in maintaining the secondary combustion which arose through the means of the air admitted as described. The accompanying sketch shows this arrangement, *a*



being the wire gauze fitted in the bridge, *b*; *d* is the incandescent drop arch deflecting the volatile hydrocarbon so as to meet the air supply at *c*.

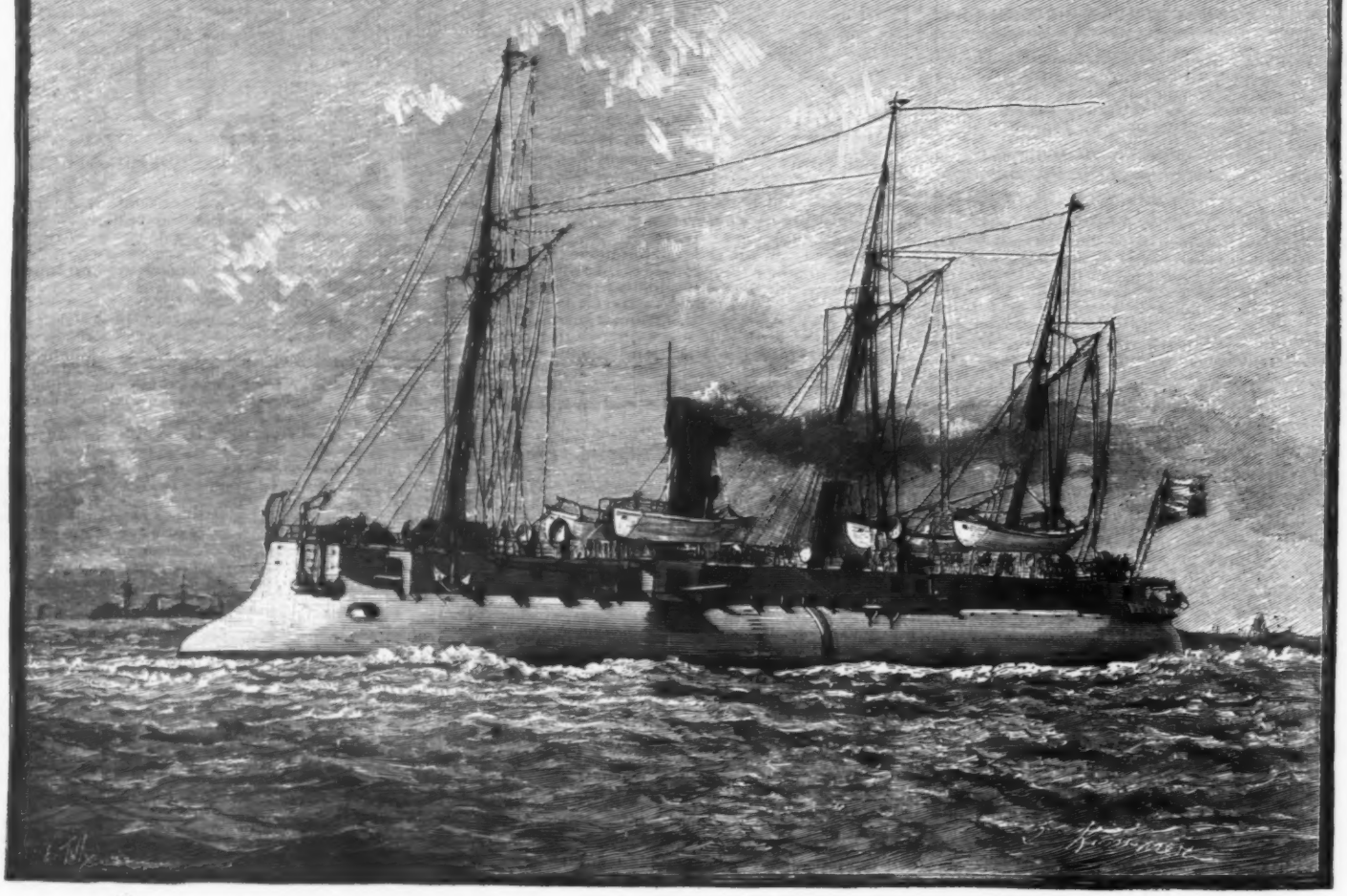
By this arrangement it was found by Mr. William Thompson, F.R.S.E., of the Chemical Laboratory, Royal Institution, Manchester, that with coal containing so high a proportion of volatile hydrocarbons as 28·35 per cent., these constituents were entirely con-

sumed, instead of being, as in the ordinary system of firing, carried up the chimney in the form of smoke or deposited upon the economizer tubes as soot.

In a few cases where the nature of the work carried on required only intermittent stoking, there being periods when a full supply of steam was a necessity, while at this time the fires remained quiescent, it became desirable to adopt means whereby the supply of air to the gauze inlet could be regulated at will, and it is to meet these cases that an addition has now been made to the annihilator. This has been effected by leading the air through two pipes laid close under the firebars, one at each angle of the bars with the flue. The air is thus heated by the proximity of the pipes to the grate, and to the boiler itself, and flows to the gauze, which is now inclosed so as to obtain its supply only by this means. At the inlet of the pipes, which are either flush with the front of the boiler or may project a little, butterfly valves are provided to regulate the amount of air admitted. It will be seen, moreover, that, by the boxing in of the resistance gauze, any possibility of the meshes being clogged with ash is entirely precluded.

THE NEW FRENCH TORPEDO CRUISER WATTIGNIES.

THE Wattignies, which was launched in April, 1891, at Rochefort, is completing its armament in that port.



THE NEW FRENCH TORPEDO CRUISER WATTIGNIES.

The following are its principal dimensions: Length 233 ft., maximum width 29 ft., depth 14 ft., draught 15 ft. The displacement of the vessel is 1,280 tons. Its engine is capable of developing 4,000 horse power. It will carry 116 tons of coal. The Wattignies ought to have a speed of 19 knots. It will be capable of covering a distance of 552 miles at the highest speed and 1,800 miles at 12½ knots.

The armament comprises: Five rapid-firing 4 inch guns arranged as follows: two in the turrets on each side of the smokestack; two in front of the mizzen mast, under the spar deck, to be used in pursuit; one in reserve on the bridge for retreat, six 2 inch rapid-firing guns, four 1·5 inch revolvers, four torpedo-launching tubes.

The vessel is provided with three powerful electrical projectors, and will have three masts.

The Wattignies will be the first vessel of our fleet provided with rapid-firing guns.

The port of Cherbourg has received an order to put on the stocks a torpedo cruiser similar to the Wattignies, to be named Fleurus.—*L'Illustration.*

STATISTICS collected abroad show that for short distances, as 1,000 yards, wire cables furnish the most efficient means of transmitting power, but for greater distances, as 5,000 yards, electricity is by far the least wasteful of all methods.

ALUMINUM.

By W. R. INGALLS, M.E.

PURE aluminum is a white metal with a decided bluish tint, which becomes more marked upon exposure. It melts at about 1,300° F., but becomes pasty at a temperature of about 1,000° F., and loses its tensile strength and very much of its rigidity at a temperature of 400° to 500° F., although this loss of strength is only while the metal is kept at the high temperature. It does not volatilize at any temperature ordinarily produced by the combustion of carbon. After silver, copper, and gold, it is the best conductor of both heat and electricity; taking the thermal conductivity of silver as 100, that of copper is 73·6, and annealed aluminum of 98·5 per cent. purity, 38·87; taking the electrical conductivity of silver as 100, that of copper is 90, and that of pure annealed aluminum about 50. Pure aluminum and commercial aluminum, with less than 0·2 per cent. iron, exhibit no appreciable polarity.

Aluminum is tough but lacks hardness and rigidity, although both these qualities may be increased by the addition of a small percentage of some other metal. Pure aluminum is a very malleable and ductile metal, standing third in the order of malleability and seventh in ductility. Like silver and gold, aluminum stiffens up remarkably in working, its hardness and tensile strength being increased, and its ductility and malleability decreased. It can be welded readily by electric welding apparatus, and can now be successfully soldered. It can be cast without difficulty in dry sand moulds, the shrinkage being $\frac{1}{64}$ in. per foot, compared with $\frac{5}{32}$ in. per foot in the case of brass.

Contrary to popular opinion, aluminum is not a non-corrodible metal. It is acted upon by the atmosphere, especially by moist atmosphere, and more especially still by moist salt atmosphere, the metal becoming covered by a thin coating of oxide, which seems to protect it from further oxidation. It is not acted upon by steam, boiling water, carbonic acid, carbonic oxide, or sulphureted hydrogen. It is soluble in hydrochloric acid, and M. Leroy has shown recently that it is acted upon by nitric and sulphuric acids uncontaminated by hydrochloric acid. Solutions of the caustic alkalies, chlorine, bromine, iodine, and fluorine rapidly corrode aluminum, and strong aqua ammonia has a slight solvent action upon it. Recent experiments by a German chemist, described in *Industrie-Blaetter*, No. 48, 1891, show that aluminum is attacked by a large number of vegetable acids at ordinary temperatures.

The specific gravity of aluminum is from 2·56 to 2·70. It has about the same ultimate tensile strength as cast iron, but under compression is comparatively weak. Mr. A. E. Hunt gives the average results of many tests of aluminium—of the composition aluminum, 97 per cent. to 99 per cent., silicon (graphitic), 0·1 per cent. to 1 per cent., silicon (combined), 0·9 per cent. to 2·8 per cent., iron, 0·04 per cent. to 0·2 per cent.—in the following table:

Tension tests.	Castings.	Sheet.	Wire.	Bars.
Elastic limit per sq. in. in lb.....	6,500	12,000	16,000 to 30,000	14,000
Ultimate strength per sq. in. in lb.....	15,000	24,000	30,000 to 60,000	28,000
Reduction of area...	15 per cent.	35 per cent.	60 per cent.	40 per cent.

Compression tests (in cylinders with length twice the diameter) showed: Elastic limit per square inch, 3,500 lb.; ultimate strength per square inch, 13,000 lb. The modulus of elasticity of cast aluminum is about 11,000,000; cold-drawn aluminum wire about 19,000,000; aluminum sheets about 13,000,000. Under transverse test pure aluminum is not a very rigid metal. An inch square bar of good cast iron, supported on knife edges 4 ft. 6 in. apart and loaded in the center, will readily stand 500 lb. without a deflection of over 2 in. A similar bar of aluminum would deflect over 2 in. with a weight of 250 lb. Aluminum, alloyed with a few per cent. of impurities and cold-rolled, or otherwise worked cold, can be made, however, nearly as strong and elastic and more rigid than mild steel.

Aluminum forms alloys with all the metals with the exception of lead, antimony, and mercury, and many of these alloys have already been proved to be very useful. The useful alloys of aluminum, so far discovered, are all in two groups, one of aluminum with less than 15 per cent. of other metals, and the other of metals containing less than 15 per cent. of aluminum; in the former case the other metals imparting hardness and other useful qualities to the aluminum, and in the latter the aluminum giving useful qualities to the other metals.

Ores of Aluminum.—The minerals which constitute the ores of aluminum are the following: *Bauxite* ($Al_2H_4O_5$), soft and granular, with 50 per cent. to 70 per cent. alumina, and only a few per cent. of accidental impurities besides the water of hydration; *corundum* (Al_2O_3), very hard and crystalline, of 3·9 specific gravity, with 93 per cent. alumina and ordinarily very free from impurities, but so hard and crystalline, and withal so valuable for other purposes, as not to be at present used as an aluminum ore; *diaspore* ($Al_2O_3H_2O$), hard and crystalline, of 3·4 specific gravity, with 64 per cent. to 85 per cent. alumina and ordinarily very pure; *cryolite* (Al_2Fl_6 6 NaFl), of 2·9 specific gravity, with 40 per cent. aluminum fluoride and 60 per cent. sodium fluoride; *aluminite* (Al_2SO_6 9 H_2O), of 1·66 specific gravity, containing about 30 per cent. of alumina in a condition to be cheaply purified by solution, filtration and roasting; *gibbsite* (Al_2O_3 3 H_2O), stalactitic, of 2·4 specific gravity, containing about 65 per cent. alumina.

Clays of various kinds contain a large percentage of alumina, but it is combined with silica, and these are not, consequently, available as ores of aluminum at the present time. Silica is much more easily reduced

than alumina, and by all methods of reduction this large percentage of silica must be separated from the alumina before the reduction is commenced, else a large percentage of energy used in reduction will be wasted.

The ore of aluminum most used is bauxite, which occurs in great abundance in Tennessee, Virginia, North and South Carolina, Georgia, Alabama, and Arkansas. The discovery of the mineral in the latter State is a comparatively recent development, having been announced by Dr. John C. Branner, State geologist, in the early part of 1891. These deposits cover an area of 640 acres in Saline and Pulaski Counties, and vary in thickness from a few feet to over 40 ft. Good bauxite used in the manufacture of aluminum is worth about $10 per ton at Pittsburg.

Another ore generally used in the manufacture of aluminum by the electric processes of the present time is cryolite, which is imported from Evigtok, near Arksut, Greenland, that being the only country in which this mineral is mined. The Evigtok mine is worked as a quarry and has been opened 450 ft. long, 150 ft. wide, and 100 ft. deep, while diamond drills have penetrated 150 ft. deeper and found cryolite all the way. The mine is located close to the water's edge in Arksut Fjord. The cryolite imported from Greenland sells for 7 cents per lb. in New York in barrel lots. The only place in the United States where cryolite is known to exist is at Pike's Peak, Colo., but no workable deposits have yet been found there. Early in the past year it was reported that a large vein of the mineral had been found, and a 2 ton lot was actually shipped, but the results of the exploration did not, apparently, come up to expectations.

Method of Winning.—Aluminum is generally produced at the present time by one of the electric smelting methods, which have almost entirely superseded the old sodium process. During the past year the Aluminum Company, Limited, which had been operating large works at Oldbury, near Birmingham, England, with the Castner process, has been obliged to abandon the manufacture of aluminum on account of the competition of the electric processes, and is now devoting itself to the manufacture of sodium only. Of the electric processes there are now four, more or less similar, in use, viz., the Cowles, Hall, Heroult, and Minet.

The general method of purification of bauxite, preliminary to the reduction to aluminum, is to calcine it with just enough sodium carbonate to form sodium aluminate, the temperature being kept below the melting point, and the mass well stirred. The incinerated mass is ground, and leached with hot water, which dissolves the sodium aluminate and leaves behind the silica and iron. The solution of sodium aluminate is then filtered off and the alumina precipitated with carbonic acid gas, filtered, washed, and dried. The alumina is next dissolved in molten cryolite (fluoride of aluminum and sodium) in suitable pots and electrolyzed, the apparatus and the details of the operation varying with the different processes.

Production.—Aluminum was first made in any quantity in 1855, its value at that time being $90 per pound; with improvements in the methods of manufacture the price was gradually reduced to $4.86 (£1) in 1887, but the recent development of the industry dates only from 1889, when the Pittsburg Reduction Company placed aluminum made by the Hall process on the market at $2 per pound. The Pittsburg Reduction Company commenced operations in November, 1888, the Cowles Electric Smelting and Aluminum Company being engaged at that time in the manufacture of aluminum alloys, but is now producing pure aluminum; these were the only companies producing pure aluminum in the United States in 1889, in which year the production amounted to 47,468 lb., valued at $97,335. The total production of aluminum in the world from 1860 to 1889 inclusive is estimated by Mr. R. L. Packard, Special Agent of the Eleventh Census, at 232,000 lb.

PRODUCTION AND IMPORTS OF ALUMINUM IN THE UNITED STATES SINCE 1870.

Year.	Imports.		Year.	Production.		Imports.	
	Amt. lb.	Value.		Amt. lb.	Value.	Amt. lb.	Value.
1870.....	....	$98·00	1881.....	....	....	517·10	$6071·00
1871.....	....	341·00	1882.....	....	....	566·50	6495·00
1872.....	....	....	1883.....	1,000	$875	426·25	5079·00
1873.....	2·00	2·00	1884.....	1,800	1,350	504·00	8416·00
1874.....	683·00	2125·00	1885.....	3,400	2,500	439·00	4736·00
1875.....	434·00	1355·00	1886.....	....	27,000	452·10	5369·00
1876.....	139·00	1412·00	1887.....	....	74,905	1260·00	12119·00
1877.....	131·00	1551·00	1888.....	19,000	65,000	1348·53	14086·00
1878.....	251·00	2978·00	1889.....	47,468	97,335	908·83	4840·00
1879.....	284·44	3423·00	1890.....	*94,881	189,762	2051·00	7062·00
1880.....	340·75	4042·00	1891.....	*163,820	163,820	+1625·05	+4073·00

* Partly estimated. † Fiscal years.

The principal producers of aluminum in Europe at the present time are the Cowles Syndicate Company, Limited, and the Metal Reduction Syndicate, Limited, of England, using the Cowles and Hall processes respectively, and the *Aluminum Industrie Actien Gesellschaft*, of Lauffen-Neuhausen, in Switzerland, which uses the Heroult process. In the United States are the Pittsburg Reduction Company, with works at Kensington, Pa., and the Cowles Electric Smelting and Aluminum Company, with works at Lockport, N. Y. The United States Aluminum Metal Company, which controls the Heroult patents in the United States, has a plant at Boonton, N. J., which was originally erected for demonstrating this process and has produced some metal, but has not been in regular operation. The Wilson Aluminum Company is now establishing works at Leakesville, N. C., for the application of a process invented by Thos. L. Wilson, and expects to be in operation early in the present year. Works are also being erected at St. Michel, Savoy, France, at which the Minet process will be used.

The production of aluminum and aluminum in alloys in the United States in 1890 was about 95,000 lb. In 1891 there has been a noticeable increase, and the total output for the year may be set down as 163,820 lb. The Cowles works have run steadily throughout the year, but the Pittsburg works were idle from April to November, during which time the plant was removed from Pittsburg to Kensington, Pa., this change having been made necessary by the failure of natural gas in Pittsburg. The new works were put in operation on November 12.

Uses.—The demand for aluminum showed a great increase in 1891 over the preceding year, and from present indications this demand is likely to still further increase as new fields for the employment of the metal are constantly being found. At the present time aluminum is being largely used to replace German silver and high grade brass and for castings for very many purposes in light moving machinery and parts of apparatus where lightness is an important element. A large amount is also used in steel castings, aluminum now being regularly employed for this purpose in almost all the important steel foundries in the United States. It is the increase in demand from the foundrymen that has, perhaps, been the most marked during the past year. Pure aluminum is also making its way into a thousand and one uses that must eventually consume enormous quantities of it; as, for instance, canteens for soldiers, cartridge shells for smokeless powder, buckles and sword scabbards, and other military accouterments; the German government having purchased a considerable quantity of metal in the United States during the autumn for this purpose; wire for telegraph and telephone purposes, harness trimmings, surgical instruments and household utensils, for all of which uses it has demonstrated its fitness in an unequivocal manner. "Aluminized zinc" (an alloy of aluminum and zinc) is being employed in brass making, affording sounder castings, increasing the strength, and giving a finer color to the brass. This "aluminized zinc" is also of advantage to the galvanizers. Aluminum bronze is coming into greater favor for wire and sheet purposes, and is now being successfully drawn and rolled by many mills which had heretofore pronounced it utterly impossible to either make it into sheets, wire or castings. Altogether there is promise that the year 1892 will surpass 1891 in the aluminum industry as 1891 has surpassed 1890.

Price.—The price of aluminum has been subject to great fluctuations during the year, owing to the competition and litigation between the Cowles Electric Smelting and Aluminum Company and the Pittsburg Reduction Company. At the beginning of the year the Pittsburg Company was offering the metal in lots over 1,000 lb. at $2 per lb., and in lots over 100 lb. at $2.50 per lb. The Cowles Company asked $1 per lb. for aluminum contained in alloys. In January the latter company offered pure aluminum at $1.25 per lb. In March the Pittsburg Company reduced its price to $1 per lb. for commercially pure aluminum and 90c. per lb. for metal below 97 per cent. and above 90 per cent. fine; the Cowles Company followed with a similar reduction. In the next month, however, Judge Ricks, of the Northern District of Ohio, before whom the suit between the two companies was pending, ordered that the price of the metal should be fixed at $1.50, or the price at which the Pittsburg Company was selling, and the Cowles Company obeyed the order, but immediately offered aluminum in alloys at 75c. per lb.

In the meanwhile the price of the metal abroad had fallen, having been sold by the *Aluminum Industrie Actien Gesellschaft*, the Aluminum Company, Limited, and the Metal Reduction Syndicate, Limited, at 81c. per lb. (for commercially pure aluminum in ton lots), while the Cowles Syndicate Company, Limited, was reported to have sold its metal in New York at 90c. per lb., a price which must have been equivalent to 73c. per lb. at the works in England. Later pure aluminum was said to have been sold in Germany at 68c. per lb.

On the first of August the price was further reduced in the United States to 50c. by the action of the Pittsburg Company, the Cowles Company following suit. This great reduction was simply a *ruse de guerre*, and probably a small amount of the metal only was disposed of at this figure. In the latter part of September the price was raised to 75c. per lb. in ton lots, and 90c. per lb. in small lots, at which figures it is now held. In November the Neuhausen Company reduced its price in Germany to 50c. to 60c. per lb.—*Eng. and Min. Jour.*

RESEARCHES AS TO THE PROPERTIES OF ALLOYS.*

By Prof. W. C. ROBERTS-AUSTEN, C.B., F.R.S.

AT the request of the Alloys Research Committee, I began in April, 1890, to investigate the effects of small admixtures of certain elements on the mechanical and physical properties of iron, copper, and lead. The committee desired me to extend an investigation I had previously made upon the application of the "periodic law" of Newlands and Mendieleef to the mechanical properties of metals. This law, as originally expressed, states that "the properties of the elements are a periodic function of their atomic weights." It had already been shown that the effect of impurities added to gold is nearly proportional to their atomic volume, the larger the volume of the atom the greater being its effect;† and it became interesting to determine whether this holds good for other metals.

The committee considered it desirable that iron should be the metal first examined; but the problem has fortunately been attacked by M. Osmond,‡ the results of whose recent investigations have gone far to show that there are two distinct varieties of pure iron, the α, or soft, and the β, or hard form; and further that the action of impurities on iron does appear to be in accordance with the periodic law. The foreign elements, whose influence on the critical points of iron he has studied experimentally with more or less completeness, are ranged as follows in two columns in the order of their atomic volumes, found by dividing their atomic weight by their specific gravity:

I.		II.	
Carbon.....	3·6	Chromium....	7·7
Boron.....	4·1	Tungsten.....	9·6
Nickel.....	6·7	Silicon.....	11·2
Manganese.....	6·9	Arsenic.....	13·2
Copper.....	7·1	Phosphorus...	13·5
		Sulphur.....	13·7

He points out that "the elements in column I., whose atomic volumes are smaller than that of iron (7·2), delay during cooling *cæteris paribus* the change of β or hard iron into α or soft iron, as well as that of "hardening carbon" (*carbone de trempe*) into "carbide carbon" (*carbone de recuit*). For these two reasons they tend to increase, with equal rates of cooling, the proportion of β or hard iron that is present in the cooled iron or steel, and consequently the hardness of the metal. Indeed, their presence is equivalent to more or less energetic hardening produced by rapid cooling. On the other hand, elements whose atomic volumes are greater than that of iron (column II.) tend to raise, or at least to maintain near its normal position during cooling, the temperature at which the change of (β) hard to (α) soft iron takes place. Further, they render the inverse change during heating more or less incomplete, and usually hasten the change of dissolved or "hardening carbon" to "carbide carbon."

Thus they maintain iron in the (α) soft state at high temperatures, and must therefore have the same effect in the cooled metal. In this way they would act on iron as annealing does, rendering it soft and malleable, did not their individual properties, or those of their compounds, mask this natural consequence of their presence. The essential part played by foreign elements alloyed with iron is therefore either to hasten or to delay the passage of iron during cooling to an allotropic state; and to render the change more or less incomplete, in one direction or the other, according to whether the atomic volume of the added impurity is greater or less than that of iron. In other words, foreign elements of low atomic volume tend to make iron itself assume or retain the particular molecular form which possesses the lowest atomic volume, while elements with large atomic volume produce the inverse effect.

It will be evident that, if iron itself can exist in two widely different states, each with properties of its own, the mechanical properties of given samples of iron and steel must depend upon the relative proportions of the two modifications of iron present in the mass. And it will also be evident that the nature of the influence of impurities on iron is far more complicated than in the case of gold, their primary effect on iron being either to hasten or to delay the passage of the metal from its normal state to another, which possesses widely different molecular aggregation, and consequently different properties. In the case of gold, it is possible that the molecular constitution of the precious metal is simpler than that of iron. Each molecule may consist of but few atoms, and therefore there may not be the same scope for pronounced change of properties which could follow rearrangement of atoms in the molecules. The action of an impurity may probably be more direct in the case of gold, as its influence is not initially exerted in rearranging the atoms in a molecule, but in affecting the mutual relations of the molecules themselves. Or it may be that the lowering of the freezing point, which is effected by the presence of impurity, may enable the cooling gold to assume a crystalline structure which is detrimental to its tenacity, if not destructive of it.

The difficulties of obtaining for mechanical tests masses of iron with only definite amounts of a single impurity are very great, and it is therefore very difficult to extend Osmond's research; but of the practical importance of his experiments there can be no question, and their full significance may become more apparent by investigating the action of impurities on some other metal, the behavior of which suggests strong probability that it can exist in an allotropic state. In view, however, of the importance of Osmond's research, it was considered desirable to confirm his main results, adopting an independent method of observation, as will be stated subsequently.

Lead, which is one of the metals the committee selected for investigation, probably exists in more than one modification. Muschenbroeck and afterward Guyton de Morveau‖ showed that the cohesive force or tenacity of lead is increased by hammering or drawing; and the latter speaks quite clearly of molecular strain produced by the mechanical treatment. Bolley† has shown that "chemically active" lead may be prepared by electrolytic action; and W. Spring‡ has gone far to show that the polymerization (or increase in the number of atoms in a molecule) of lead-tin alloys may take place at temperatures below their melting points. The observation made by Coriolis, § that lead increases in hardness by successive meltings, even if protected from oxidation, may not be without significance. I have made a great many experiments on the mechanical properties of lead as affected by a small quantity of impurity; but as yet it has not been found possible to obtain definite or even concordant results. The tenacity and extensibility of lead seem to be greatly influenced by the temperature at which the metal is cast, and the difficulty of avoiding the presence of flaws and blowholes is very great. This portion of the inquiry has therefore been set aside for the present, as it is probable that more valuable evidence of allotropic changes will be afforded by thermal than by mechanical measurements.

PYROMETER.

In order to cary out the investigation a really trustworthy pyrometer is required. The admirable investigations of Callendar ‖ with the pyrometer of Siemens have restored the confidence in it, which had been shaken by a report of a committee of the British Association.¶ The action of this instrument depends on

* Report to the Alloys Research Committee, British Institution of Mechanical Engineers.

† *Philosophical Transactions* of the Royal Society. Vol. 179, 1888, p. 339.

‡ *Comptes Rendus*. Vol. cx., 1890, p. 346. The results of his experiments are given in detail in the *Journal* of the Iron and Steel Institute, 1890, part 1, p. 38.

* *Annales de Chemie*, Vol. lxxi., 1809, pp. 189–199.

† Liebig und Kopp, *Jahresbuch*, 1849, p. 278.

‡ *Bulletin de l'Academie Royal de Belgique* [3], Vol. xi., No. 5, 1886.

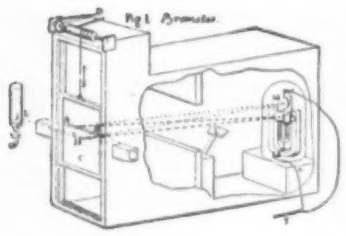
§ *Annales de Chimie et de Physique*, Vol. xliv., 1830, p. 103.

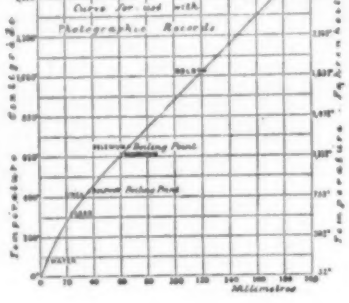
‖ Philosophical Transactions of the Royal Society, Vol. clxxviii., 1887, p. 161.

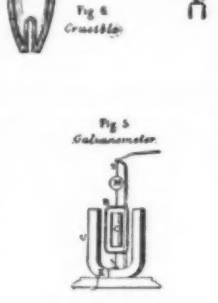
¶ Report of the British Association, 1874, p. 242.

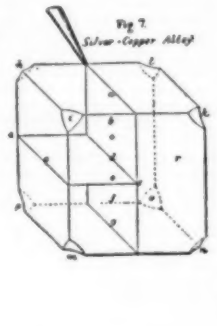
the variation of resistance presented by a heated platinum wire placed in one branch of a divided circuit, and it is trustworthy for temperatures up to 500° C. or 900° F. Messrs. Callendar and Smith* have shown that with platinum resistance thermometers a degree of accuracy of the order of 0·01° C. or 0·02° F. may be attained at temperatures between 100° and 450° C. or 212° and 840° F.

In the present investigation it is necessary to measure much higher temperatures; and fortunately an accurate method is at hand. Early in 1889 I had occasion to employ the pyrometer devised by Mr. H. Le Chatelier, and was satisfied as to its being extremely trustworthy and convenient up to temperatures over 1,000° C. or 1,800° F. The instrument, in fact, enabled me to confirm the fundamental observations of M. Osmond respecting the critical points of iron and steel, and to demonstrate the results in a lecture delivered before the members of the British Association in September, 1889.† Le Chatelier's pyrometer I believe had not previously been employed in this country, and it may be









well to describe it in some detail, as such an instrument has long been needed, and can hardly fail to be of much use to engineers. The pyrometer‡ consists of a thermo-couple of platinum and platinum containing ten per cent. of rhodium.

Thermo-couples have long been used; but as is pointed out by Barus § in an elaborate memoir only recently published, the earlier investigators unfortunately employed unsuitable metals, iron and palladium, which, from the readiness with which they absorb gases and consequently undergo molecular change, are of all metals probably the least suited for thermo-electric pyrometry. Osmond's work alone would show that iron is specially unsuitable for high temperature thermo-couples. Le Chatelier's pyrometer is based on the measurement of the electric current produced by heating a thermo-junction inserted in a circuit with a galvanometer of considerable resistance. As already stated, this thermo-couple consists of two wires, each about 0·5 mm. or 0·02 inch diameter, one of which is of pure platinum and the other of platinum containing 10 per cent. of rhodium. The junction of the wires may simply be effected by twisting them together in either of the forms indicated by the sketches, Fig. 3 or Fig. 4. The junction may be welded, or soldered with gold, no flux being used; but neither of these methods seems to possess any advantage over a double twist. The junction may be viewed as a battery; for when it is heated a current of electricity is generated, no other source of electricity being employed. It is asserted that even long wires of the platinum-rhodium alloy are homogeneous, and therefore do not give rise to subsidiary currents, which would disturb the effect of the main current produced by heating the junction; but very careful experiments to determine whether this is the case have yet to be made. From analogy with platinum-gold alloys, it may be doubted whether the platinum-rhodium alloy is of absolutely uniform composition. The thermo-electric properties of platinum-rhodium wire are said to be hardly altered by stress, or by exposure to rapid alternations of temperature; nor does the nature of the gaseous atmosphere in which the couple is placed appear to render its action untrustworthy. The present experiments have shown that the wires must certainly be protected from the vapor of silver, or from contact with carbon or silicon. The free ends of the platinum and platinum-rhodium wires are soldered to copper terminals, which are kept at a constant temperature by being plunged into test tubes filled with alcohol and immersed in water, the temperature of which can be observed with a thermometer. The thermo-couple measures the difference of temperature between its heated junction and the copper terminals.

The galvanometer which appears to be best suited for use in connection with the couple is a reflecting dead-beat one, which bears the names of Deprez and d'Arsonval; it is now well known in this country. That

* *Proceedings* of the Royal Society, Vol. xlviii., 1890, p. 230.

† *Nature*, Vol. xli., Nov., 1889, pp. 11, 32.

‡ *Journal de Physique*, Vol. vi., Jan., 1889, p. 23.

§ Bulletin of the United States Geological Survey, No. 54, 1889.

employed in the following experiments* has an internal resistance of 200 ohms. The arrangement of the several parts is shown in Fig. 5, in which U is a magnet, B a coil of wire suspended by a German silver wire, S S, and moving freely round an iron core, C, and M is a mirror carried by the same wire, S. The steadiness of the spot of light upon the screen when the circuit is closed is remarkable.

GRADUATION OF PYROMETER.

The electromotive force produced by heating the thermo-junction to any given temperature is measured by the movement of the spot of light on the scale graduated in millimeters. A formula for converting the divisions of the scale into thermometric degrees is given by M. Le Chatelier; but it is far better to calibrate the scale by heating the thermo-junction to temperatures which have been very carefully determined by the aid of the air thermometer, and then to plot the curve from the data so obtained. Many fusion and boiling points have been established by concurrent evidence of various kinds, and are now very generally accepted. The following table contains certain of these:

Deg. F.	Deg. F.		
212	100	Boiling point of water.	
618	326	Melting point of lead.	
676	358	Boiling point of mercury.	
779	415	Melting point of zinc.	
838	448	Boiling point of sulphur.	
1,157	625	Melting point of aluminum.	
1,229	665	Boiling point of selenium.	
1,733	945	Melting point of silver.	
1,859	1,015	" "	potassium sulphate.
1,913	1,045	" "	gold.
1,929	1,054	" "	copper.
2,732	1,500	" "	palladium.
3,227	1,775	" "	platinum.

The known temperatures employed for calibrating the thermo-junction referred to in this report are the boiling point of water 100° C., the melting points of lead 326°, zinc 415°, and aluminum 625°, the boiling points of sulphur 448°, and selenium 665°, and the melting point of potassium sulphate 1,015°. The melting point of silver, 945°, is one of the points which rests on more evidence than any other. I find, however, that when it is carefully determined and interpolated in the curve, the number is only 920° C.; this is doubtless owing to retention of gas by the metal. The melting point of gold, 1,045° C., and Violle's † determination of that of palladium, 1,500°, are generally accepted. These several fixed temperatures have been used as the basis of the calibration.

In Fig. 2 these temperatures are taken as ordinates, while the abscissæ are the deviations of the spot of light which marks the temperature at the thermo-junction.

It will be evident, since these points fall so close to an even curve, that much confidence may be placed in the trustworthy nature of the pyrometer. It may be noted that the position here marked for the boiling point of water, namely, at about 90° C., is, of course, not the true boiling point of water, but is the difference between the true boiling point, 100° C., and the observed temperature, 10° C., of the cold junction of the pyrometer. In the various determinations the latter temperature varied from 10° to 15° C., or 50° to 60° F.

It was hardly to be expected that the determination of the melting point of palladium would yield a figure which falls so fairly into line with lower melting points; and it may be well to add a few details as to the manipulation. A globule of palladium weighing about 2 grammes or 30 grains may readily be melted by placing the metal in a cavity in a sound piece of charcoal. The charcoal near the button is ignited, and a stream of oxygen from a fine clay tube about 1 mm. or 0·04 in. diameter is directed into the cavity. A very manageable source of intense heat is thus obtained; and a fused globule of gold or palladium may be tilted on to the junction conveniently placed in the cavity, and then allowed to cool there. The globule may, in fact, be melted on or shaken off the junction as readily as a drop of wax; and the slight arrests of the spot of light, which mark the true points of fusion and solidification, can readily be detected by a practiced observer. It has already been shown by M. Le Chatelier that soldering the junction with gold in no way diminishes its sensitiveness; and this appears to be true of palladium. The wires, however, after brief exposure to the alloying metals at this very high temperature, rapidly become destroyed and broken. In some cases, as in that of determining the melting point of potassium sulphate, the thermo-junction may be plunged without covering into the midst of the mass, which is gradually being raised to its fusion point. In the case of a metal, the thermo-junction may either be surrounded by a portion of the metal or a strip or globule of the metal may be placed in a crucible filled with some substance difficult of fusion—silica or calcined magnesia—in close proximity to the thermo-junction. The temperature is very gradually and steadily raised, until the metal begins to fuse. A Fletcher oxygen furnace answers well. The moment at which fusion begins is indicated by an arrest in the movement of the spot of light, followed, if the mass of metal be small, by a rapid forward movement when the fusion is complete. The point that the spot of light has attained on the graduated scale at the moment of its arrest is the point to note as the melting point of the metal. A little practice will enable this point to be readily determined; but all uncertainty in the matter is removed by reducing the spot of light to a fine vertical line and securing a photographic record of its movement.

The following plan may therefore be recommended when a high degree of accuracy is required. The vertical line of light, from an Argand gas burner, L, and mirror, H, Fig. 1, is reflected from the mirror, M, of the galvanometer, and is allowed to fall upon a sensitized plate through a carefully adjusted horizontal slit, A B. Eastman's gelatine films have been found to answer well. The slit entirely crosses the plate, which is made to travel upward at a uniform rate by gearing, D, driven by clockwork; the regularity of the rate of travel may be tested by a time signal in seconds, produced by periodically obscuring, by the interrupter, E, worked by a clock, the light from a second fixed mirror, F, placed immediately below the suspended mirror, M, of the galvanometer, so as to send a fixed beam of light to the zero of the galvanometer mirror scale, that is, to the further end of the horizontal slit, A B.

The amplitude of the deflection of the galvanometer mirror, M, will of course depend on the temperature to which the thermo-junction, T, is heated. The same source of light illuminates both mirrors; and the result is, first, a beaded datum line from the intermittent light of the fixed mirror, F, which gives the rate of travel of the plate; and second, a continuous curve which is photographically traced by the line of light from the galvanometer mirror, M, this photographic curve being the resultant of the movements of the tiny spot of light and of the sensitive plate.

The nature of the photographic curve in the case of a melting point may be illustrated by that which represents the fusion and solidification of a mass of aluminum weighing 10 grammes or 150 grains. The thermo-junction was in this case protected by a thin covering of pipe clay 1 mm. or 0·04 in. thick. While the plate is at rest the spot of light traces the straight line, *e f*, Fig. 9; then as the plate advances it traces the somewhat sinuous curve, *f g*, owing to the necessarily irregular heating of the mass of metal; but it is arrested at *a* when fusion begins, and a line parallel to the datum line is traced until the mass is fluid, when the temperature is raised above the melting point, as is shown by the portion of the curve marked *b*. The gas being then turned off, the metal cools and freezes, as is indicated by the second arrest, *c*, at a point slightly below its melting point.

It will be evident that a chronographic record might

* Constructed by M. Carpentier, 20 Rue Delambre, Paris.

† *Philosophical Magazine*, Vol. viii. (Series V.), 1879, p. 501, and Vol. xlii., 1882, p. 147; *Comptes Rendus*, Vol. lxxxix., No. 17, pp. 702, 709.

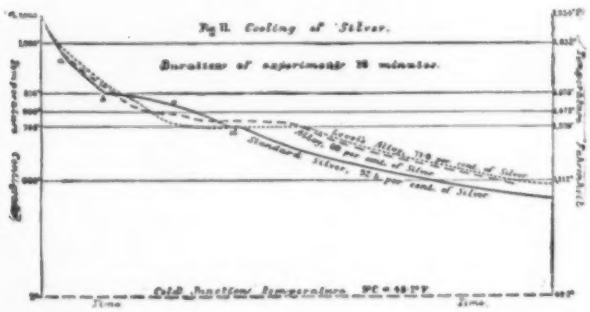
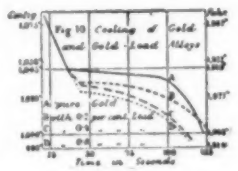


Fig 11. Cooling of Silver.
Duration of experiment 18 minutes.
Standard Silver, 92·5 per cent. of Silver
Cold Junction Temperature 18° C = 64·4° F.
Time.



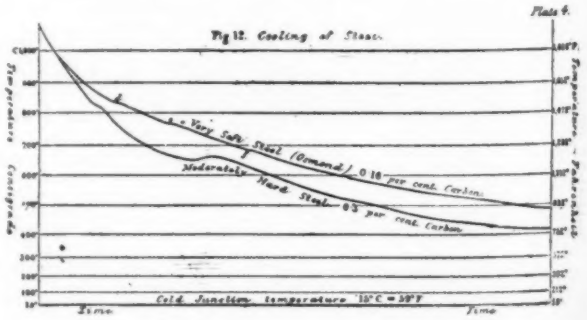


Plate 4.
Fig 12. Cooling of Steel.
Very Soft Steel (Ormand) 0·10 per cent. Carbon.
Moderately Hard Steel 0·5 per cent. Carbon.
Cold Junction temperature 10° C = 50° F.
Time.

replace the photographic one. In fact, in beginning the investigation the chronographic method was employed. The time taken by the spot of light from the galvanometer to pass each division of a transparent graduated scale was noted on the paper ribbon of a delicate Bain instrument by an electric signal, side by side with a series of electric time signals from a clock beating half seconds. This method, though very delicate, involves much labor in the translation of the ribbon and in plotting the curves, and is, therefore, much less convenient than the photographic one, which gives a curve automatically.

The calculations by which the final results are obtained are as follows: From the curve representing a particular experiment the temperature of any point of interest may be obtained by reference to the calibration curve. This temperature has to be corrected, first, for error, e, in indications of the galvanometer, due to change of its temperature; and, second, for alteration, j, in the temperature of the cold junctions.

The measurement of temperature by the thermo-junction depends, as is well known, on the measurement of an electromotive force by means of the current set up in a circuit of known resistance. Theoretically there are a number of corrections to make, such as those which arise from the varying resistance of the junction itself and of the leads; but the comparatively high resistance of the galvanometer renders these insignificant. Thus the resistance of the wires forming the couple was in one experiment 2·42 ohms, of the leads 0·175 ohm, and of the galvanometer 201·ohms. The part of the wires heated to a high temperature was too short to form an appreciable part of the resistance, even if its own resistance were doubled. Consequently the first correction, e, reduces itself to a simple temperature correction, applied to the galvanometer. This at first sight might appear to involve several corrections: first, a correction for change c in resistance of the coil; second, a correction for variation v in the torsion of the suspending wire; third, a correction for any modification m of the magnetic field of the galvanometer.

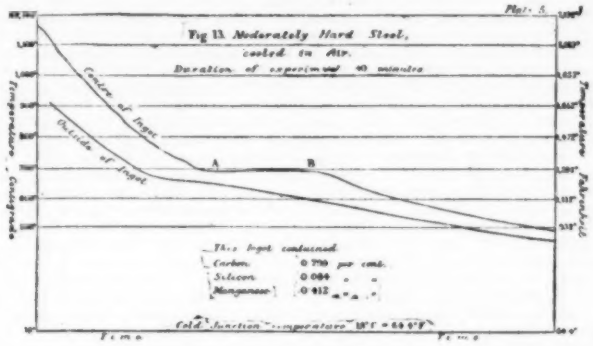
The correction for change c in resistance of the coil is easily made. The coil is of German silver, which has a temperature coefficient of 0·00038 per degree Centigrade. The deflection at the melting point of gold is 16 centimeters upon the scale; hence a rise in temperature of 1° C. decreases the deflection from 16 to 15·994.

The variation v in the torsional resistance of the suspending wire was found to be quite negligible. Time readings were taken of the oscillations of the mirror, 500 consecutive oscillations being taken several times each day on different days and at different temperatures. No difference in time of oscillations greater than 0·2 second could be detected with a stop watch. One indirect effect, however, was observed. The pillar of the instrument supporting the wire and coil does not appear to be made of the same material as the suspending wire itself; and as this suspending wire has some initial torsional strain, the zero of the instrument changes slightly with changes of temperature. After this was discovered special care was taken to watch the zero.

The modification m of the field in which the coil hangs is probably very small; any alteration would be at once checked and provided for by the system of introducing known high temperatures.

The temperature as indicated by the deflection of the mirror has also to be corrected for variation j in the temperature of the cold junctions. Obviously the pyrometer measures only the differences of temperature between the copper junctions and the junction of the special wires; but by keeping the former at one temperature the indications of the pyrometer are measures of the difference between this temperature and that of the heated couple. The curve connecting the deflections with their corresponding temperatures is very nearly a straight line throughout the range of the experiments; and consequently it is legitimate to add to or subtract from the deflection an amount corresponding with the small variation of the cold junction from some normal temperature taken at 18° C. This correction and that for change in resistance of the coil of the galvanometer are applied to the observed deflection produced by the source of heat, the temperature of which was to be determined. This deflection is then compared with the deflection (also corrected) that is obtained by the introduction of known high temperatures, usually afforded by a crucible filled with pure molten gold; and the difference multiplied by the constant obtained from the part of the calibration curve (of the particular wire) which corresponds to the range of temperature, gives the difference in degrees Centigrade from the known high temperature.

If the thermo-junction be ruptured, the ends of the wires may be joined again after the removal of the defective part. Nevertheless, in conducting a series of experiments it is very desirable to employ for as long as possible the same thermo-junction; and it is therefore necessary to adopt precautions with a view to its preservation. This gives rise to considerable difficulty, in view of the absolute necessity for bringing the couple into close proximity to the molten metal; and several methods of protecting the couple were adopted. Clay coverings were open to the objection of their fragility under sudden exposure to heat; and this entails the risk of spoiling a thermo-couple in the midst of an investigation. Inclosing the junction in little tubes of iron filled with silver answers very well for comparatively low temperatures; but iron alloys readily with many metals into which the tube would have to be inserted; for instance, the iron-protected junction could not be plunged into molten gold. Ultimately blocks were cut from portions of large "plumbago pots" used in mint work, and were carefully fashioned in the lathe into small crucibles of the ordinary shape, but provided with a tube or socket extending vertically from the base up to about one-third the height of the crucible, as shown in the section, Fig. 6. The thermo-couple could then be inserted in the tube, which was surrounded by the molten metal. The Morgan Crucible Company have since made crucibles of this pattern specially for this research. This plan was independently devised for the purposes of the present research; it had, however, been anticipated by Barus,* who used a similar arrangement on a larger scale for determining the boiling points of metals. In ascertaining the point of solidification of a metal, the crucible filled with metal is withdrawn from the furnace, and placed over the thermo-junction, so that the wires are near the top of the tube, but do not touch its sides. To prevent them from doing so, a cap made of sheet platinum is always kept fitted over them, and probably is specially useful in protecting the platinum wires from being contaminated with silicon and carbon, which Callendar † has already shown to increase the resistance of platinum wires; they certainly injure the wires mechanically.



LIQUATION OF SILVER-COPPER ALLOYS.

In order to gain some evidence as to the capabilities of the appliance, it was subjected to the following tests in connection with the liquation of silver-copper alloys, that is, the separation of their more fusible constituents. This series of alloys has previously been the subject of careful experiment, and much is now known respecting them. Not the least interesting fact connected with them is the remarkable molecular rearrangement they undergo during solidification. Levol,‡ who is the chief authority on the subject, concluded that the only homogeneous alloy contains 71·89 per cent. of silver and 28·107 per cent. of copper; and he considers it to be a definite combination of the two metals having the formula $Ag_3 Cu_2$. Many years ago I also examined the behavior of the silver-copper alloys during cooling; and the following figures and diagram, Fig. 7, taken from my paper,§ may be given, as showing the way in which a cubical mass, 45 mm. or 1¾ in. side, will arrange itself in cooling rapidly. It will be evident that the silver becomes concentrated toward the center of the mass, which is richer in silver by 1·28 per cent. than the external portions.

ALLOY CONTAINING 92·5 PER CENT. SILVER AND 7·5 PER CENT. COPPER, COOLED RAPIDLY. (SEE FIG. 7.)

Central vertical plane.	Percentage of silver.	Corners.	Percentage of silver.	Sides.	Percentage of silver.
a	92·46	h	92·32	q	92·36
b	92·60	i	92·37	r	92·38
c	92·91	k	92·33	s	92·31
d	93·55	l	92·33		
e	93·10	m	92·39		
f	92·50	n	92·38		
g	92·42	o	92·27	Dip assay	92·51
		p	92·32		

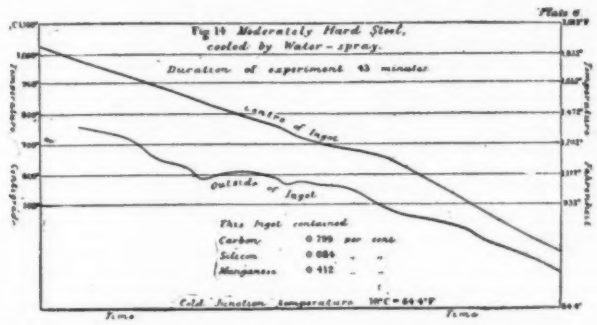
Maximum difference, between center d and corner o, 1·28.

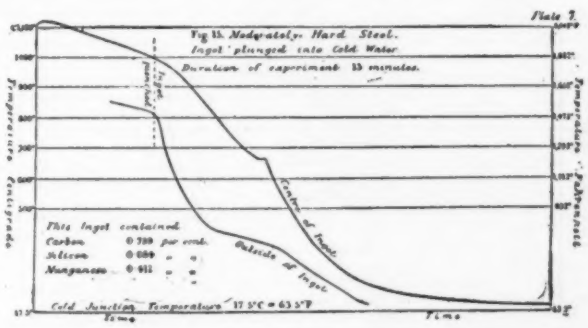
The results of a memorable research led Guthrie* to the conclusion that certain alloys in cooling "throw off atomically definite bodies, leaving behind a fluid mass which is not definite in composition;" so that ultimately the most fusible alloy of the series is left, which he calls the *eutectic* or most fusible alloy, and in it the "proportions between the constituent metals are not atomic proportions." Guthrie's experiments dealt only with alloys of low melting points, such as the fusible metals; but photographic records of the rate of cooling, as measured by the platinum and platinum-rhodium thermo-couple, might be expected to show at what temperatures groups of silver-copper alloys soldify and fall out of solution. And at the same time evidence as to the probable composition of the eutectic alloy of the series should be as readily obtained by these means as it was, in the earlier experiments, by placing an ordinary mercurial thermometer in a bath of fusible metal.

Fig. 11 represents such a photographic record of the rate of cooling of a mass of standard silver weighing 11 oz. It will be seen that the initial temperature indicated is 1,068° C., and that there is an abrupt fall to 856° C. at b, when the freezing of the mass as a whole begins. Just before this abrupt turn in the curve takes place there is a slight change in its direction at a, probably caused by a falling out of alloys rich in copper. After the abrupt break at b a slight upward tendency, c, shows that heat is evolved; but the curve continues to fall until another abrupt change occurs at 748° at d, which indicates that a second critical point has been reached. That this is attended by the evolution of heat is seen, for the spot of light remains stationary for 40 seconds; and it is doubtless caused by the soldification of the eutectic alloy, that is, the most fusible alloy of the series.

Similar photographic records of the cooling of Levol's alloy, $Ag_3 Cu_2$, containing 71·893 per cent. of silver, show that there is only a single break, Fig. 11, which occurs at this same temperature, 748° C.; soldification throughout the mass then takes place. A record of the cooling of a mass of silver-copper, Ag Cu, containing 63·029 per cent. of silver, also gives only a single break at 748° C.; but, although the freezing point of the eutectic alloy is evidently close to this temperature of 748° C., it would not be safe to conclude that either $Ag_3 Cu_2$ or Ag Cu is itself the eutectic alloy; they are probably only the last alloys (in which the constituents are in simple atomic proportions) to fall out of a bath of indefinite composition. Other alloys of this series have been examined, and the curve of the one containing 60 per cent. of silver is also shown in Fig. 11. It seems to show that in a series of alloys the second point of solidification is not quite constant. The behavior of a solidifying mass of gun metal appears to present exactly the same characteristics; but the experiments have not as yet been concluded. It is easy in the case of alloys like fusible metal to keep the alloy melted, and to ascertain what the composition of the most fusible alloy really is, by repeatedly straining the fluid mass from the suspended crystals through a canvas or asbestos bag. The temperature required to separate the eutectic alloy of the silver-copper series would introduce many difficulties of manipulation, though the result might ultimately be obtained.

The accompanying photographic curve, Fig. 12, shows the application of the photographic method to recording the evolution of heat which occurs in cooling masses of steel. The experiment was made on a piece of the same steel which had already been subjected to experiments by M. Osmond. It had the following composition: Carbon, 0·160 per cent.; silicon, 0·012 per cent.; sulphur, 0·021 per cent.; phosphorus, 0·029 per cent.; manganese, 0·110 per cent. The results of cooling it are shown by the upper curve in Fig. 12. It will be observed that as the mass cooled down there were, as M. Osmond had shown, two distinct evolutions of heat: one, d, occurs at 843° C. or 1,549° F., which is believed to mark the change of hard to soft iron, because it occurs in iron free from carbon; and the other, f, is at 675° C. or 1,247° F., and is certainly due to the change in the relations between the carbon and the iron. There is





* Bulletin of the United States Geological Survey, No. 54, 1889, p. 92.

† *Philosophical Transactions* of the Royal Society, Vol. clxxviii., 1887, p. 161.

‡ *Annales de Chimie et de Physique*, Vol. xxxvi., 1852, p. 193; Vol. xxxix., 1853, p. 163.

§ *Proceedings* of the Royal Society, Vol. xxiii., 1874-5, p. 481.

* *Philosophical Magazine*, Vol. xvii., 1884, p. 462.

probably also another slight evolution of heat, *e*, at 767° C. or 1473° F. It is interesting to compare this curve with the one below it, obtained during the cooling of a mass of steel containing nearly 0·5 per cent. of carbon, in which there is a distinct evolution of heat at 820° C. or 1,508° F., and a prolonged one at 650° C. or 1,202° F. With reference to these curves, M. Osmond himself wrote to me on December 18th, 1890: "The photographs are very beautiful, but, as you say, this mode of representation [by time-temperature] is not well adapted for showing slight evolutions of heat which occur while the cooling of the mass is slow [and is represented by the flat part of the curve]. It is certain, however, that the slightest prominence shown in the curve is a real one, and is not due to errors of plotting. The curve representing my steel is perfectly clear, but your specimen appears to have been well chosen for showing the two critical points."

EFFECT OF SMALL QUANTITIES OF IMPURITY ON THE FREEZING POINT OF GOLD.

The fundamental effect of an impurity in modifying the mechanical properties of metals has been abundantly established; but the part played by the impurity may be twofold. It may act directly on its own account upon the mass; and, by changing its structure, may alter its mechanical properties when solid. Or, as Osmond's* work has shown, it may cause, retard, or hasten the passage of a metal in which it is hidden from its normal to an allotropic state, and may affect its properties indirectly. For the purpose of investigating these two distinct sets of phenomena, gold offers many advantages. It may be prepared in a very high degree of purity; it is not liable to contamination by oxidation; and much is already known respecting certain of its mechanical and thermal† properties as influenced by small quantities of impurity, which exert a truly astonishing influence on its strength and extensibility. Platinum would no doubt be even better; but its manipulation is attended with many difficulties. In the case of gold such difficulties can be met; and when they have been surmounted the work may be carried on with confidence, so as to prepare for the extension of the experiments to metals in ordinary use. It would appear, therefore, most desirable to obtain thermal evidence as to the influence of impurities on a cooling mass of gold. In what degree, for instance, is the freezing point of gold influenced by the presence of definite impurities? And is the final solidification of the mass preceded in the respective stages by a pasty stage? Or does the passage from the fluid to the solid state take place rapidly? Many years ago I called attention to the remarkable lowering in the melting point of gold produced by the presence of silicon; but the want of a suitable pyrometer has hitherto prevented my making direct experiments upon the subject.

The method of preparing gold of a high degree of purity has already been described.‡ In each experiment now to be more fully described, 132 grammes, or 2,037 grains, of gold were melted in one of the crucibles provided with a central tube or socket, as already described, and weighing, with its cover, 130 grammes, or 2,006 grains.

The initial temperature of the molten mass was high, somewhere about 1,200° C. or 2,200° F.; and the durability of the thermo-junction and the constancy of its readings had therefore to be carefully tested. It was found by repeated trials that different crucibles of the same size, filled with identical weights of gold, gave closely concordant results; but it occasionally happened that the platinum wire of the couple became brittle and broke. In such cases the fractured portion was removed, and the ends were twisted together again. Throughout the course of the experiments, a crucible filled with pure gold was kept at hand, and the freezing point of the molten metal was determined from time to time as a check.

The object of the experiments was primarily to ascertain whether the influence of impurities on the metal was really tangible, that is, whether the insertion of the point of a fine stirrer of clay would indicate the existence of a pasty or gritty stage; but advantage was taken of the installation of the appliances to determine what retardation of the freezing point of gold is produced by the known elements which are added to it.

The result of Raoult's investigations on the lowering of the freezing points of solutions led him to the conclusion that one molecular proportion of any substance, dissolved in a hundred molecular proportions of any solvent whatever, lowers the freezing point of that solvent 0·62° C. or 1·12° F. This had not been tested in the case of solutions of metals in metals until Heycock and Neville § began an elaborate investigation of the subject. Their research, as far as it has at present been carried, deals first with lowering the freezing points of sodium and tin, produced by the addition to them of certain metals; and, second, with the molecular weights of metals when in solution. The results of their experiments when compared with the empirical laws of Coppet and Raoult may be briefly stated as follows: They are in accordance with the law that "for moderate concentration the fall in the freezing point is proportional to the weight of the dissolved substance present in a constant weight of solvent." By making the assumption that the molecule of zinc or of mercury is monatomic when in solution in tin, they confirm the second law that "when the falls produced in the same solvent by different dissolved substances are compared, it is found that a molecular weight of a dissolved substance produces the same fall, whatever the substance is." But the third law, which states that "if a constant number of molecular weights of the solvent be taken, the fall is independent of the nature of the solvent," they found to be probably incorrect, and theoretical considerations, indeed, would lead us to expect this. In the case of silicon in standard gold, which has already been mentioned, a long semi-fluid stage appears to be set up. The metal may contain solidified particles, and yet be sufficiently fluid to flow readily. This phenomenon has not yet been fully investigated.

In a research of much interest, Ramsay* has determined the molecular weight of a number of metals by Raoult's vapor pressure method; that is, he ascertained the depression of the vapor pressure of the solvent, produced by a known weight of dissolved substance, and he finds that although sodium behaves irregularly, yet "it would appear legitimate to infer that in solution, as a rule, the atom of a metal is identical with its molecule, as the physical properties of those metals which have been vaporized would lead us to suppose."

The experiments were conducted as follows: The gold was melted in the crucible and its freezing point noted in two ways: first, by recording with the aid of a chronograph the rate at which the mass cooled, the results being plotted in a curve with time and temperature as co-ordinates. The exact freezing point was then indicated by the abrupt change in the direction of the curve. Second, freezing point was also actually observed in the following way: The cover of the crucible had an orifice, which could be covered with a plug of charcoal, and through this orifice was inserted a fine pipe clay rod held in the hand. A little experience with this, in touching the surface of the molten mass, enabled the existence of either a pasty or a gritty stage to be detected, and the point of actual solidification to be noted; and this point was telegraphed on to the chronograph tape by a distinctive sign. The gold was then remelted, and the impurity to be added was carefully weighed, wrapped in pure gold foil, and added to the molten mass, which was well stirred with a fine clay stirrer, and replaced in the furnace to make sure that the mass was thoroughly fluid. The crucible was placed in position over the thermo-junction, and the freezing point observed as before. Lead and bismuth exert great influence in diminishing the tenacity and extensibility of gold. They were therefore first selected with a view to study their action upon its freezing point. In the gold lead series, Fig. 10, the full curve A is the normal line, representing the freezing of pure gold, and the dotted curves B C D were obtained as the results of successive additions of lead, B corresponding with 0·2 per cent., C with 0·4 per cent., and D with 0·8 per cent. of lead. The lowering of the freezing point was found to be proportional to the amount of lead added. No marked pasty stage was detected, and the lowering of the freezing point appears to be about 19° C. or 34° F. for every atom of lead added to 100 atoms of gold.

The calculations are as follows: The atomic theory assumes that there are as many atoms in 196 parts by weight of gold as there are in 208 parts by weight of lead. Consequently, if 0·2 per cent. of lead be added to a mass of gold, there will be $0{\cdot}2 \times 196 \div 208 = 0{\cdot}19$ atom of lead per hundred atoms of gold. Dividing the observed fall of the freezing point in degrees Centigrade by the number of atoms of impurity which causes it in a hundred atoms of gold, the figure known as the "atomic fall" is obtained; and this is nearly constant for any given mass of an individual metal. As soon as 0·3 per cent. of lead is present, oxidation causes a little trouble; and apparently a simple molecular action gives place to one of more complex character, the result being that the further alteration of the freezing point is not so great as it was initially.

The series with bismuth showed a very regular lowering of the temperature of the freezing point, giving an atomic fall of 17° C. or 31° F. up to 2 per cent. or 3 per cent. of bismuth. Even with 19 per cent. of bismuth there is a point well marked in the curve showing where solidification commences. A study of these curves gives rise to a suspicion that a "trace" of impurity has an important effect upon the latent and specific heats; but until the experiments are repeated under very accurate calorimetric conditions, this point is uncertain. Bismuth probably gives a eutectic alloy of very low melting point, the pasty stage being maintained down to temperatures differing but little from that of melting lead; but the experiments have not been carried further at present. It is remarkable that a small quantity of bismuth in gold produces a lead gray or almost purple color of the fractured surface, which, upon burnishing, becomes at once golden yellow. This is doubtless due to the very distinct liquation that can be observed, the granules of nearly pure gold being surrounded by a brittle and impure mass.

Platinum gave an interesting series of results, which indicated an atomic fall of 17° C. or 31° F. But gold is very soon saturated with platinum; apparently 0·6 per cent. is sufficient for that purpose. The first addition of platinum at once stopped the "piping" of the solidifying mass, which is so marked a feature in very pure gold, and gave the characteristic crystalline surface which indicates the presence of platinum. An accident prevented the series from being carried beyond 1 per cent. of platinum, which amount, however, is sufficient to raise the freezing point again to that of pure gold.

Silicon, which has a small atomic weight, exerts a great influence on the freezing point of gold; but much difficulty was experienced in getting it to alloy with the gold. The fall produced was at the rate of 16° C. or 29° F. for each atom in a hundred atoms of gold.

Manganese was also somewhat difficult to alloy‖; but after the union of the gold and manganese had been effected the mass behaved in a peculiar way, indicating considerable internal changes in their mode of association near the freezing point. The bath remained quite mirror-like and limpid until the freezing point was reached; it then suddenly clouded over, and a granular mass began to form. The results were remarkable from the fact that the atomic fall was found to be only one-half that obtained in most other cases; thus there is reason to conclude that manganese exists in this particular instance as a diatomic molecule.

The effect of aluminum was also studied, on account of the interest it possesses in connection with the metallurgy of iron. The gold combined with this metal with avidity, and when cold the fracture showed very marked granular structure. A study of the curve indicates that an almost chaotic state is produced in the gold by the addition of aluminum; not only is the point of initial freezing lowered, but the metal only partially solidifies during a very long range of temperature, and could easily be poured at several hundred degrees lower than the initial freezing point. This in all probability is the reason for the conflict of opinion as to the amount and nature of the change produced in the freezing point of wrought iron by the presence of aluminum, as in the case of the well known "mitis" castings. The long pasty stage which aluminum sets up is very deceptive, and renders it difficult to determine which is the true freezing point. Aluminum has a low atomic weight, and causes a very considerable fall in the freezing point of gold; this fall, however, is only one-third of that produced per atom by other impurities.

Silver occupies a remarkable position in the series. Very pure silver was used, which had been tested by Stas; but it required nearly 5 per cent. of silver to cause any appreciable lowering of the freezing point. Whether solid gold is capable of dissolving silver cannot yet be proved; but it opens an extremely interesting field for research.

STEEL.

From the engineer's point of view the most interesting information which the pyrometer has as yet afforded is connected with the measurement of internal stresses in iron and steel. Osmond's work has shown that molecular changes take place in steel; and it is evident that the occurrence of these changes must be of vital importance when the metal is subjected at high temperatures to mechanical operations such as a rolling or forging. The question naturally arises, Do the molecular changes in the iron take place at one moment throughout the mass of metal? that is, is the rate of cooling approximately uniform throughout the mass? Or does the external portion of a hot ingot cool so much more rapidly than the center as to allow the molecular changes in the iron, and the alterations in the relation between the carbon and the iron, to become completed near the surface long before they take place in the interior of the mass? The experimental difficulties in the way of obtaining information upon these points have hitherto appeared to be insuperable; but the pyrometric method used in this research affords most important evidence, as a brief description of the following experiments will show:

Two thermo-junctions made from adjacent pieces off the same coils of wire, and both insulated in the ordinary way by means of pipe clay tubes, were carefully prepared. A miniature ingot of mild steel, 4 in. diameter and 8 in. long, shown in section in Fig. 8, was provided by the Director-General of Ordnance Factories; one hole $\frac{5}{8}$ in. diameter was drilled from the center of one end to a depth of 4 in., and another hole of the same diameter was drilled near the edge of the same end to a depth of 1 in. The ingot was then heated to bright redness in a furnace; and when it had been withdrawn, the two thermo-junctions were inserted, one in each of the holes. Then, by means of a special switch, they were alternately connected for short but measured periods of time with the galvanometer of the photographic recording apparatus. Curves were thus obtained from *both* the thermo-junctions simultaneously, each curve being made up of short dashes. In the case of mild steel the evidence as to molecular change was but slight, but with a single ingot of moderately hard steel the results, which are shown in Figs. 13, 14 and 15, are very interesting. This ingot contained 0·799 per cent. of carbon, 0·084 per cent. of silicon and 0·412 per cent. of manganese.

In Fig. 13, which represents the cooling of the ingot in air, the upper curve records the cooling of the center of the ingot and the lower the cooling of the outer portion. The initial temperature at the center was 1,160° C. or 2,120° F. The molecular change in the iron can be detected at 880° C. or 1,616° F., and the carbon change takes place at 696° C. or 1,285° F. In the lower curve, representing the cooling of the circumference, the carbon change takes place no less than four minutes earlier than at the center, and at the lower temperature of 665° C. or 1,229° F. as compared with 696° C. or 1,285° F. This is a most interesting point, as Osmond has already shown that the rate of cooling has a measurable effect upon the temperatures at which molecular change occurs. The great internal strain which must be set up between the points marked A and B in the upper curve is evident when it is borne in mind that the carbon change is accompanied by a considerable alteration of volume.

In Fig. 14 is shown a pair of curves obtained from the same ingot when cooled by a water spray. These present but few additional points of interest.

In the experiment represented by Fig. 15 the ingot was plunged, when its exterior was at a temperature of 850° C. or 1,560° F., into a tank of cold water. The lower curve, however, representing the rate of cooling of the outer portions of the ingot, is not strictly autographic, as it was slightly defective on the original photographic plate for temperatures below 600° C. or 1,100° F. The upper curve is autographic throughout.

In all these experiments it was found that the flow of heat from the center of such an ingot was not sufficiently rapid to prevent there being considerable variations in temperature within the mass. There can be but little question that such experiments will deserve careful attention, and in the hands of competent observers should be fruitful of results.

A NEW ELECTRO-DEPOSITED ALLOY.

IT has always been advanced by those who view alloys as true chemical compounds that the fact that certain of them can be deposited electrically lends countenance to their view. Seeing that brass was almost the only alloy of which the deposition was successfully practiced, the position lacked strength from the scanty evidence supporting it. Lately, however, several attempts have been made to deposit other alloys, and that, too, on a commercial scale. The process of plating recently patented by the London Metallurgical Plating Company, under the significant name of "Arcas," has gone through several stages of development, and, according to the *Engineer*, in its newest form presents several features of interest. To begin with, a metal—the use of which has been hitherto confined to the production of an artist's pigment, to the formation of fusible alloys, and to the aid of the photographer—which is similar to zinc, and associated with it in its ores, namely, cadmium, has been made to do duty in a larger field. Instead of the alloy of zinc and

---

* *Comptes Rendus*, vol. cx., 1890, p. 346.

† *Annales de Chimie et de Physique*, vol. xx., 1890, p. 66.

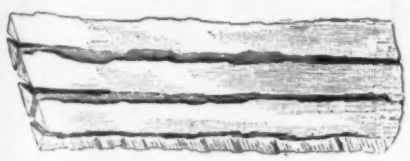
‡ *Philosophical Transactions* of the Royal Society, vol. clxxix., 1888, pp. 339-349.

§ Riemidijk, *Journal of the Chemical Society*, vol. lv., 1889, p. 666; vol. lvii., 1890, pp. 376 and 666.

* *Journal of the Chemical Society*, vol. lv., 1889, p. 521. See also Tammann, *Zeitschrift fur physikalische Chemie*, 1888, p. 441.

silver which was first chosen for the production of "Arcas plating," one containing cadmium is now preferred. The change at first sight would seem to be for the worse, as cadmium is about twelve times the price of zinc, but as silver is in its turn more than twelve times the price of cadmium, the fact that an alloy containing only two-thirds the quantity of silver previously necessary can be used turns the balance of advantage in the opposite direction. In the original "Arcas" alloy, 90 per cent. of silver and 10 per cent. of zinc were used, while in the latest substitute the proportions are about 65 per cent. of silver and 35 per cent. of cadmium.

Other alloys may be used for special purposes, notably when cheapness is the first consideration, and the percentage of cadmium is then increased up to as much as 90 per cent. Alloys containing rather more than 40 per cent. of cadmium are difficult to deal with, on account of their being liable to split during rolling. The appearance of a rolled anode in which this has happened is shown in the accompanying figure, the lines



of cleavage being very curious in their regularity. It is not easy to see what can be the cause of the geometrical fissures, but it seems probable that some segregation of the constituent metals from top to bottom of the plate must take place, as alternate strips differ slightly but appreciably in color. The rolling of the other alloys can be effected without difficulty, and as is usual in electro-plating, rolled anodes are preferred to cast. Another working difficulty was met with and surmounted. It consisted in the tendency displayed by the electrolyte to cut through the anodes at the point where they entered the liquid. This was got over by the following means: In the plating tank the electrodes are suspended on a frame resting on the edge of the bath. This frame is fitted with rollers which run on the tank edge and short inclines thereon. The frame is connected by a rod from an eccentric turning on a shaft which runs from end to end of each set of tanks. By the two motions which are thus obtained, the tray oscillates horizontally through a stroke of about 2¼ in. and simultaneously has a vertical movement of about ¾ in. By this means the lighter liquor, poorer in metal and richer in the non-metallic radical, is prevented from collecting at the top and attacking the anode unduly at that point, and the uniformity of the bath is secured. The baths are usually worked cold, and are composed of the cyanides of silver and cadmium dissolved in excess of potassium cyanide. Plating by this method is in appearance as brilliant and of as good a color as silver, and is said not to tarnish with sulphurous gases in the manner unhappily characteristic of that metal. By suitably varying the conditions of deposition, a bright coating can be obtained, and thus burnishing saved, a noteworthy advantage for cheap goods, which are plated too thinly to stand much polishing.

FIELD MAGNETS.

THE field magnets of a dynamo-electric machine constitute one of the two of its most essential parts. The other part is the armature.

The field magnets are constructed of several parts, namely, the magnet cores (of which there are usually two), the yoke piece, the pole pieces, and the wire with which the magnets are wound.

The accompanying illustration shows these various

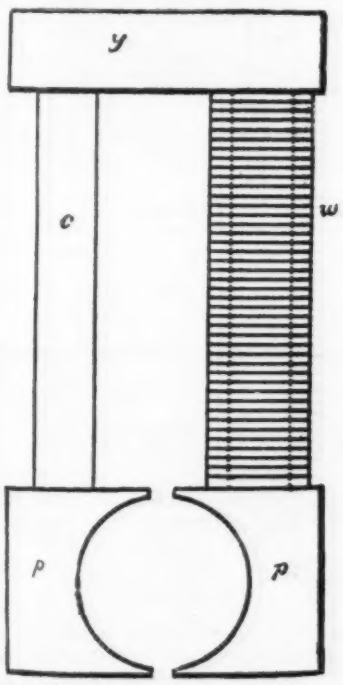


DIAGRAM OF FIELD MAGNETS.

y, yoke; *c*, magnet core; *w*, magnet windings; *p*, *p*, pole pieces.

parts and the manner of assembling them to make the field magnets complete.

There are many forms of dynamos in use, but the one illustrated in the diagram is in no essential respect different from all the others.

The function of the field magnets is to create and maintain a magnetic field in which the armature may revolve. As a rule, dynamos are so built that the field magnets are stationary while the armature revolves. Some machines are made, however, with stationary armatures and revolving magnets. One part *must* move. This is manifest when we think for a moment that in order to create a difference of potential in the wire of the armature, or, in other words, generate a current, that wire must cut through the magnetic lines of force in the magnetic field. This implies motion.

The material used for the different parts of field magnets is the softest iron procurable, except in the case of the wire, which is of copper. Soft iron is used, because with it, it is possible to produce a much more powerful magnetic field than if any other quality were used. Iron is the essential metal to use always for magnets in all classes of electrical instruments, on account of its high magnetic properties; that is to say, it is the best conductor of magnetism. Metals are divided into two classes with reference to their magnetic behavior, viz., magnetic and non-magnetic. Copper is classed as a non-magnetic metal, while iron is the most magnetic; hence the importance of iron in the construction of magnets will be readily understood.

There are as many different forms of dynamos as there are makers—no two being alike. As the field magnets usually constitute the most prominent part of dynamos, the difference in form of machines relates wholly to the shape of the field magnets, although there are structural differences in different makes of armatures as well. These, however, are not readily noticeable to the observer.

The form of dynamo illustrated in our figure requires a yoke, the function of which is to effect continuity in the magnetic circuit. Without the yoke the magnetic field surrounding the armature would be infinitely weaker, and the machine would be practically valueless. All dynamos do not possess a yoke piece; indeed, some dynamo field magnets are constructed on the typical horseshoe form, and consequently require no yoke. The form shown in the figure is a modification of the horseshoe; instead of the curve it has corners.

The pole pieces are really enlargements of the core, so as to increase the surface of magnetic action, and are constructed with curves on their inner surfaces, so as to cover the surface of the armature as completely as possible, and yet have a break in the continuity of the magnetic circuit.

These pole pieces are really the "poles" of the electromagnet. We all know that a horseshoe (permanent) magnet is strongest at its poles; so, in the case of a dynamo, the magnetism is strongest at the pole pieces, and as the lines flow from one pole to the other, according to the direction of the current flowing in the magnet wire, they must necessarily flow or act through the space between the pole pieces. As this space is filled with the magnetic lines of force, and as the wire on the armature must cut lines of force in order to effect a difference of potential, and consequently generate a current, the armature is placed in this space, or magnetic field, as it is usually called.

Concerning the magnetic field we will say more later on.

The cores of the field magnets are generally made round. Some, however, are elliptical in shape. They are never made square or in any other form possessing points or corners, because such projections become "poles" themselves, and as it is essential to have all the magnetic influence concentrated at two points, namely, the pole pieces, the importance of adopting every means possible to convey the magnetic lines to these points is manifest; hence the round form is adopted for magnet cores. In the case of the yoke piece the magnetism is very weak, or practically *nil* at that part of the magnetic circuit. Hence the existence of the corners makes no material difference in practical results.

The magnetism is strongest between the pole pieces and weakest at the yoke.

As to the winding of the magnets, of course, that involves many factors in its calculation, and as it is not within the scope of these articles to consider intricate problems of this nature, we refer those of our readers who desire to go into the subject further to any one of the text books which are now published, giving all such information. An excellent work of this class is "Principles of Dynamo-Electric Machines," by Carl Hering.*

Copper wire, of course, is always used for magnet windings. It is covered with some insulating material in order to keep the windings from touching one another. The copper must be of the purest quality obtainable in order to keep the resistance down to a minimum. The size of the wire is determined by calculations based on the work that will be required of the machine.

Some dynamo field magnets are wound with two coils. Such machines are known as compound-wound dynamos.

It is important to have all joints between the parts of a field magnet very secure and reliable, so as to interpose no resistance in the magnetic circuit.—*The Electrical Age.*

THE HOMACOUSTIC.

FEW of our readers, we fear, will recognize under this name the ingenious appliance which, for distances up to 100 yards at least, is rapidly displacing the telephone. They will, however, be more likely to know it by the two illustrations which accompany this notice. The instrument is really a speaking tube of an improved kind, and there is little or nothing about it to get out of order as there is in a telephone, nor is it possible for the wires to get mixed, and the user be rung up in mistake for some one else, or for him to overhear a private conversation between a man at his office and his wife at their house. We have seen the instrument in several offices lately, and it gave satisfaction to the officials at the Naval Exhibition, but it is not of its usefulness in these directions that we now desire to speak. What concerns us is its applicability to the needs of life on board ship. Before, however, we go further we must explain what the instrument really is.

All our readers know the ordinary speaking tube and the absurd way in which a conversation is conducted through one. Great scope is given for pantomime artists and such gentlemen as Mr. Corney Grain to imitate the troubles of one who maintains a conversation through an ordinary speaking tube. First you have to blow down it to make it whistle at the other end. Then you have to put your ear to it to hear if the whistle has been heard. Then the conversation begins. Perhaps the person at the other end is speaking when you speak; then, as he is not listening and cannot be—for no man can have his mouth and ear at the end of a tube at the same time—all the con-

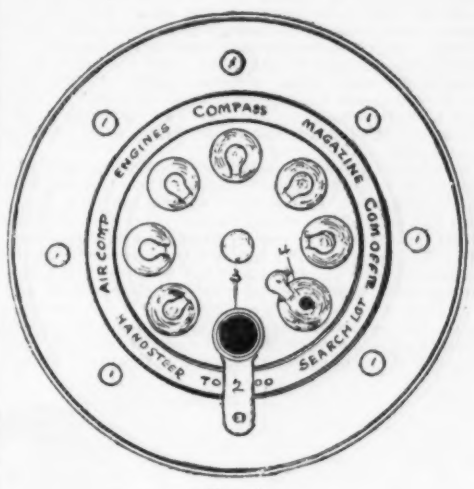


FIG. 1.

versation has to be commenced *de novo*. It may be funny to see this process taken off by a professional entertainer, but it grows monotonous to the busy man, and no wonder that the speaking tube was getting displaced by the telephone in hotels and manufactories and other big buildings. But Cutmore's patent—the Homacoustic—is changing all that, and showing that by a simple improvement all the disadvantages of the speaking tube may be abolished. In the first place there is a funnel, springing out from the wall or stand, into which one speaks. In the tube, a few inches behind it, is a cock with a plug leading a flexible tube out through the side, with an ear cup. The arrangement is such that when the ear cup is allowed to hang down, the passage to the mouthpiece is closed. When the ear cup is raised to the level of the ear, the passage to the mouthpiece is opened, and at the same time the voice from the other end of the tubes comes down the flexible portion to the listener. In addition to these appliances there is on the top of the instrument a metal ball with a cylinder projecting above it. When the attention of the person at the other end is to be

FIG. 2.

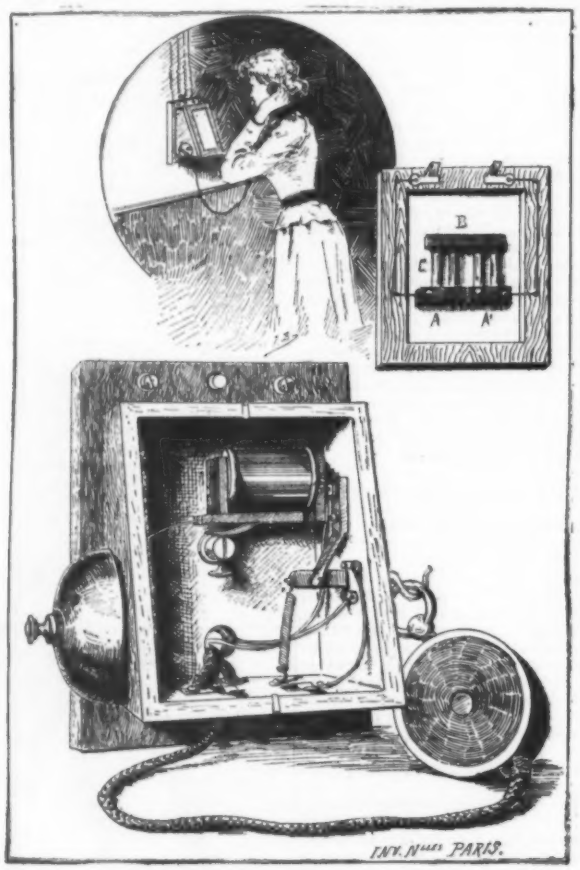
called it is merely necessary to press the cylinder down into the ball. This displaces the air, the earpiece hanging down the cock is closed, and the air cannot escape through the mouthpiece. It, therefore, has to travel down the tube, and whistles at the other end. Then taking up the earpiece and putting it to the ear, the cock is opened and a conversation can be at once

* Price, $2.50. This book, as well as all others on electrical subjects, can be obtained at the office of the SCIENTIFIC AMERICAN, New York.

maintained, both speaking and hearing going on simultaneously. There is a conical shaped baffle plate in the mouthpiece to prevent the sounds getting mixed.

This, then, is the instrument in its simplest form, but it is capable of various combinations, though the principle is always the same. Thus for use in engine rooms and factories, where there is likely to be much noise, earpieces for both ears are provided, and these have India rubber rings round them which fit tight to the head, and thus exclude all other sounds, however loud. The form we illustrate is one for use in a wheel house or a conning tower. From it tubes are laid on to all the important parts of the vessel, such as the engine room, magazine, search light, compass, hand steering gear, captain's room, ventilating machinery, and so on, as may be required. All the tubes communicating with these different parts of the ship are led up inside the pedestal, and arranged so that each is exactly the same distance away from its neighbor as are the holes in the swivel plates above it from one another.

An electric bell communication is also supplied, and though there are so many tubes, there is only one speaking and receiving instrument. As it is desired to speak with any part of the vessel, the swivel is moved round till the mouthpiece is directly above the tube required. Attention may then be called either by touching the electric button (which is indicated by a dot just below the figure 2) or by pressing the whistle cylinder, and communication is at once established. If, on the other hand, the engine room or other part of the vessel wishes to make a report to the bridge, it sends its call, and the corresponding cap (as 4 in the plan) springs



DOMESTIC TELEPHONE.

open and shows which of the numerous tubes needs attention.

Our explanation may be cumbersome, but the idea is simple and clever, and will be readily comprehended by any one who sees it for a moment, and doubtless many of our readers have used it at the Crystal Palace Electric Exhibition. We should mention that the patentees have a special material, with good acoustic properties, for making tubes, though the instrument can be fitted to any existing ones. We have said enough to show that the instrument, which has so little to get out of order and has no chemicals to waste, no lines to get entangled or broken, has a great future before it.—*The Marine Engineer.*

A DOMESTIC TELEPHONE.

THE domestic telephone represented in the accompanying figure has been especially devised with the object of offering to the public an apparatus as perfect, as regards operation, as those at present in use, and at a price far more within reach of every one's purse.

Although the apparatus is especially designed for short distance transmissions, for example, for hotels, villas, country houses, large manufactories, and ordinary apartments, it may, nevertheless, serve to advantage for establishing communications at distances of several miles.

It is distinguished by the following peculiarities: The transmitter is a microphone of the Hughes kind, modified and improved so as to suppress the inconveniences that this apparatus, so valuable for demonstration, nevertheless presents in practice. The Hughes microphone is too sensitive; it sizzles, and, the contact failing, the transmission is too often no longer integral. In order to overcome these troubles, the inventor has made the following improvements: (1) He gives a certain inclination; 2 he causes the carbons (which are rounded at the extremity) to rest upon a plane surface—an arrangement that assures both contact and mobility; and (3) he separates the upper part of the movable carbon from the vibrating plate by a special method of fixation which prevents the upper carbon from contact with the frame of the microphone.

The microphone employed consists of four vertical carbons united in tension by their apex, AA', and in quantity by their lower extremity, B.

The side figure presents a section showing the mounting of the carbons upon the vibrating plate.

When the apparatus is to be used for telephony to a distance, the inventor adds to it a special bobbin composed of an ordinary bobbin divided into several unequal parts—five, for example. Upon the parts 2 and 4 is wound coarse wire, the entrances and exits of which are united, the free extremities being, on another hand, connected in turn either with a pole of an electric source or with one of the sides of the microphone. On the parts 1, 3 and 5 is wound fine wire of a resistance of about 120 ohms. The core is formed of a bundle of soft iron wires. At the time of the passage of the electric current, the bobbins 2 and 4 act like those of an ordinary electro-magnet, magnetizing the extremities 1, 3 and 5 of the soft iron. Moreover, through induction, they produce in the wire a current the reverse of the primary one, at the time of its formation, but of the same direction at the time of the breaking of this same current. If the microphone is influenced by the voice, as the bobbin is in the circuit, it will therefore give rise to a reduced current capable in its turn of influencing the receiver. On the other hand, the latter is a magnetic one of the Jannin type, whose inventor obtains a maximum of intensity by suppressing the disk that keeps the diaphragm at a distance, and by substituting for it a central core which is regulatable proportionally to the force of the currents.—*Les Inventions Nouvelles.*

IMPROVEMENT IN DYNAMO AND MOTOR CONSTRUCTION.

IT is the general, in fact almost invariable, practice of dynamo and motor builders in designing machines to leave quite an appreciable air space between the armature body and the field poles. In other words, the armature is mounted on a shaft so that it may turn in proximity to, but out of contact with, the field poles.

Prof. Sidney H. Short of Cleveland, however, has concluded that he can dispense with the air space, and the accompanying cuts illustrate a machine in which he proposes to run the armature directly in contact with the field poles.

In the new machine, by dispensing with the air space and allowing the armature to run in contact with the fields, the magnetic resistance of the interpolar space is diminished, and through the increase of the relative number of the lines of force passing through the armature, the field magnets can be reduced in size and be excited with a less number of ampere turns, although exercising an equal effect in the machine.

Referring to the diagrams presented herewith, Fig. 1 shows the details of construction of Prof. Short's machine.

The machine shown has the poles of the field magnet, A, presented to the periphery of a drum armature, B, but the modification is applicable to other styles of machine, as for instance those with ring armatures and field magnets presented to the periphery, and to those with ring armatures and field magnets presented to the sides of the armatures. The field magnets are excited by the coils, C. The armature, B, has a laminated toothed core composed of a number of soft iron plates, 2, strung on a shaft, 3, and pressed together by the nut, 4, tapped on said shaft and forcing the plates against the head, 5. The bobbins, 6, are wound in the spaces between the teeth, 7, on the plates, 2. Outside the bobbins is the iron ring, 8, which is fastened to the core by a central row of bare rivets, 9, and is in close proximity to the ends of the teeth, 7, but is separated

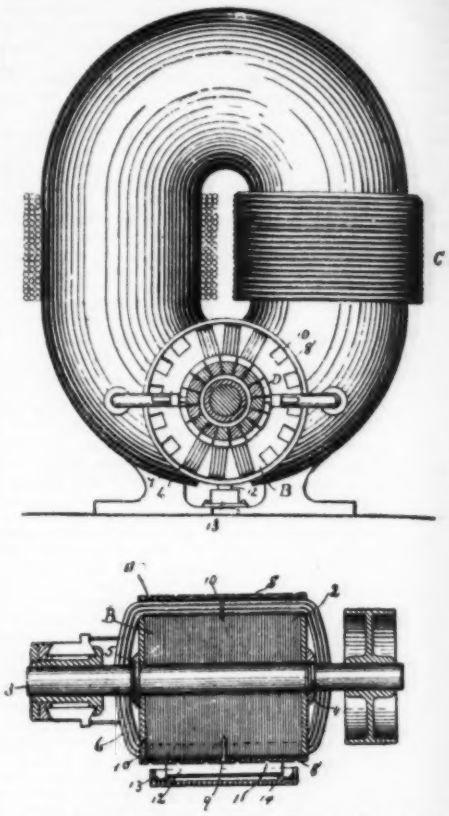
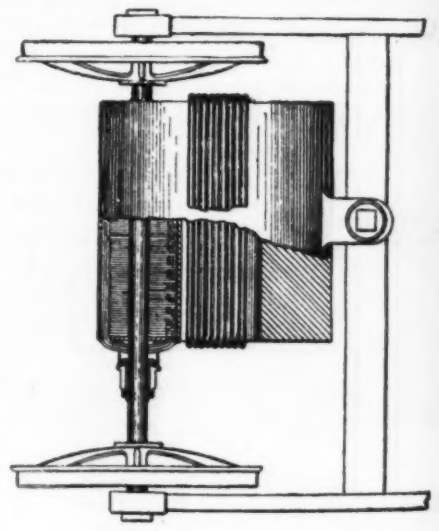


FIG. 1.—DEPARTURE IN DYNAMO AND MOTOR CONSTRUCTION.

electrically from it by the insulation, 10. The core may be made solid and the ring, 8, might rest directly on the ends of the teeth, or the teeth might project beyond the bobbins. The omission of insulation would, however, in the machine, as shown, establish circuits for eddy currents, and the interruption of the magnetic surface of the armature (as by having the teeth turn in contact with the field magnets) would tend to make



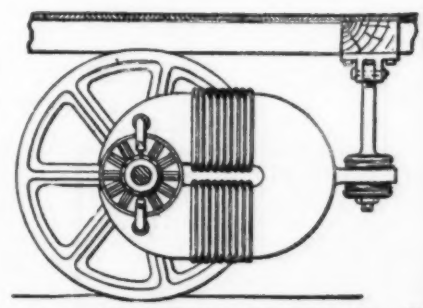


FIG. 2.—DEPARTURE IN DYNAMO AND MOTOR CONSTRUCTION.

the machine run less smoothly than with the continuous outside ring.

The armature, B, is journaled in a bearing constituted by field magnets, A, the bearing being between the outer surface of the ring, 8, and the adjacent surface of the field poles. The outer surface of the ring, 8, is shown as provided with grooves, 11, for carrying lubricating material, which is supplied to the bearing

by a felt, 12, whose lower end dips into the lubricant cup, 13, of non-magnetic material, and which is pressed against the ring, 8, by a spring, 14. The magnetic attraction holds the armature from endwise motion.

The machine, it is claimed, can be run in any position, means being provided to prevent endwise motion of the armature when the magnetic attraction is insufficient to hold it in place in the field, or when, for any reason, such means are considered desirable. By using field magnets of the form shown or a similar form placed upright, so that the lifting of the armature tends to shorten the magnetic circuit, the magnetic attraction will act against gravity and gravity against the attraction, thus minimizing the pressure at the bearing between the armature and field magnets.

The invention has been shown embodied in a two-pole machine, but it is applicable, also, to machines with four or more poles. Instead of having the armature rotate in the field magnets, these could, of course, turn on the armature.

Prof. Short claims the journaling of the armature at the periphery has certain advantages over the ordinary arrangement of a shaft and bearings, irrespective of its utility in enabling the armature to turn in contact with the field poles. One advantage is that it brings the journal bearing in the space about the armature, so that the latter with its journal bearing takes up no more width than the armature itself.

Fig. 2 shows diagrammatically Prof. Short's application of his modified type of motor to a street car. From the data already given the reader will be able to understand the arrangement with but little explanation. In the street car motor the armature is mounted fast on the car axle. It is of the drum type and is composed of a number of toothed plates of soft iron fastened together and wrapped with the bobbin wire. On the periphery of the armature is an annular iron shell, which is insulated from the toothed armature core which it surrounds. The outer surface of this shell is turned off, so that it may constitute the journal, and the shell turns in the polar extensions of the field magnets in contact with the poles of the magnets. By thus utilizing the outside of the armature for the journal bearing, not only is a long bearing secured, but no space for bearings need be left between the armature and the car wheels.—*Western Electrician.*

THE GREAT VICTORIA FALLS.

LIVINGSTONE was the first to describe to us the great falls of the upper Zambesi River, which he called the Victoria Falls. These falls are among the greatest in the world. The latest visitor to them is Mr. Decle, a French explorer, who is now carrying out ethnological investigations in the upper Zambesi region. He has made some remarks about these falls which give us a different impression of them from that commonly held.

He says that all his predecessors have spoken so enthusiastically of the falls that he hardly dares to express his own opinion. "I will content myself," he adds, "by saying that they would be very grand if one could only see them. The great river, about a mile wide at this place, suddenly contracts and disappears, apparently into the bowels of the earth, falling from a height which I estimate at about 400 ft. into a gorge which is about 500 ft. wide. The water dashes itself with such violence to the bottom of this gorge that much of it rebounds high in the air, and a column of spray and vapor rises at least 300 feet above the level of the river. One can see this column, plainly marking the location of the falls, seven miles away, and their roar can be heard for several miles. I could find no position where I could see the bottom of the gorge, and there was only a single place where it was possible for me to see as much as 600 ft. in width of the falls at one time. It is impossible to compare the Victoria Falls with those of Niagara. The latter are very grand and the former are terrific, but more on account of what we imagine than because of what we can see."

HIMALAYAN GLACIERS OF BALTISTAN.

THE sublime features and aspects of rock and ice scenery at great mountain heights, with the laws of physical science revealed by such phenomena, have engaged many explorers in the present age. An expedition of much importance is undertaken this year in a region which seems to invite strenuous efforts with a view to scientific knowledge. Baltistan, sometimes called Little Thibet, is a small province of the Maharajah of Kashmir's territory, north of Kashmir, bounded on the north by the Mustakh or Mooz-dagh Mountains, a portion of the Western Himalayas, separating it from Yarkand, and to the east by the Karakorum range, a prolongation of the Hindoo Koosh. The pass over the Mustakh leads to the Baltoro glacier, which is the largest known to exist on the surface of the globe, except in the Arctic or Antarctic regions. It is to be visited this year by a party of explorers to make ascents of peaks in its vicinity. Mr. Conway is in charge, accompanied by the Hon. G. C. Bruce, of the Indian Army, Mr. J. H. Rondebosch, Mr. A. D. McCormick, an artist, and Mr. Oscar Eckenstein, a photographer, with a Swiss guide, one Mathias Zurbriggen, and a Goorkha servant of Lieutenant Bruce. Both the Royal Society and Royal Geographical Society assist the expedition by grants.

Our illustrations are from sketches taken by Lieutenant-Colonel H. H. Godwin-Austen, who made the survey of this portion of the Himalayas in the summers of 1860 and 1861, and gave a detailed account, with map, in the Royal Geographical Society's Proceedings of 1864. The main glacier is thirty-five miles long, with an average breadth of over one mile. Its tributary ice streams arise on the precipices, gullies and slopes of peaks that rise to 28,278 ft.; the West Gusherbrum Peak, 26,103 ft., and others, on the main Mustakh, nowhere under 19,500 ft. on the northern side. The range to the south is of similar great altitude, with one peak, called Masherbrum, reaching 25,676 ft., and another 25,119 ft. In the lower part of this glacier are numerous moraines, ridges of rock, and lakes of diverse colors, with miniature floating icebergs. The terminal cliff is a mile long and 100 ft. high. Our view of the glacier, with the Gusherbrum Peaks at its head, and Mount Godwin-Austen (marked K 2 in the survey) on the right hand side, was sketched from a lower spur of Mount Masherbrum. The rate of movement of these Himalayan glaciers has never been observed. It will be examined by Mr. Conway's expedition, with many other details of interest relating to glacial action.—*Illustrated London News.*

THE HIMALAYAS—THE BALTORO GLACIER, WITH THE GUSHERBRUM PEAKS.

VIEW FROM LOWER SPUR OF MASHERBRUM—HIGHEST PEAK 26,103 FEET.

MILDEW OF THE GRAPE.

THE disease particularly referred to in the following is known among viticulturists as "downy mildew," "brown" or "gray rot" of the grape, and to scientists as *Peronospora viticola*, was very severe last year in many grape-growing districts. It has been particularly destructive in the Eastern and Central States, and also in Western Ontario. Last year it was prevalent in vineyards in the Province of Quebec, and also in the Ottawa Valley.

As a rule it is first noticed on the fruit when about half formed, presenting a downy and frosted appearance, which gives place to a grayish brown in the later stages. The berries shrivel and fall to the ground when slightly shaken. Beginning with one or two varieties in the vineyard, the disease, if allowed to run its course, will spread rapidly, attacking other kinds which were at first entirely exempt.

It usually affects the leaves and wood later in the season, sometimes in the case of early varieties after the fruit has been gathered. This stage of the disease was prominent as affecting the Roger Hybrids in the experimental farm vineyard last season.

At first it is seen on the upper surface of the leaf, showing in brown spots, while the lower surface presents the frosted appearance resembling that form of the disease affecting the fruit. This particular leaf form is not easily detected on grapes having the thick pubescent leaves characteristic of the Concord family.

TREATMENT.

Carbonate of copper	2 oz.
Ammonia	1¼ pint.
Water	25 gals.

As soon as the mildew made its appearance last year on our vines they were thoroughly sprayed with the above mixture. Two applications and the removal of all diseased berries had the effect of checking the spread of the malady, but at the same time demonstrated—when compared with the results of my former experiments—that the proper line of treatment leading to complete success lies in the *early application* of the remedy.

When the vines are uncovered spray with a simple solution of copper sulphate, 1 lb. dissolved in 15 gallons of water. Spray using the above formula soon after the fruit sets; make two or three additional applications at intervals of ten days or two weeks as the necessities of the case seem to demand. Remove and destroy diseased parts of fruit and foliage.—*John Craig, Horticulturist to Experimental Farms.*

ELEPHANTS, RECENT AND EXTINCT.

By R. LYDEKKER, B.A. Cantab.

ASSUREDLY of all the mammals now inhabiting this earth, elephants are those most justly entitled to the epithet "antediluvian," since they remind us, far more vividly than any of their modern contemporaries, of the gigantic extinct mammals of various kinds which flourished in that latest epoch of geological history when man was but a comparatively new comer. A long acquaintance has, indeed, made us so familiar with the appearance of elephants that we are too apt to forget what altogether strange and uncouth creatures they really are. If, however, they had happened to be included among those animals which disappeared from the face of the earth before the historic period, and were known to us solely by their skeletons, there can be no doubt that they would be regarded as among the most remarkable of mammals. Moreover, if elephants were only known to us by their skeletons, it would be more than doubtful if we should ever have attained a correct idea of their true form; since, although the conformation of their jaws and teeth would clearly indicate that they must have had some very peculiar method of feeding, it would have required a very bold, not to say a very imaginative man to have conceived the idea that these creatures were furnished with that unique organ which we term the trunk or proboscis.

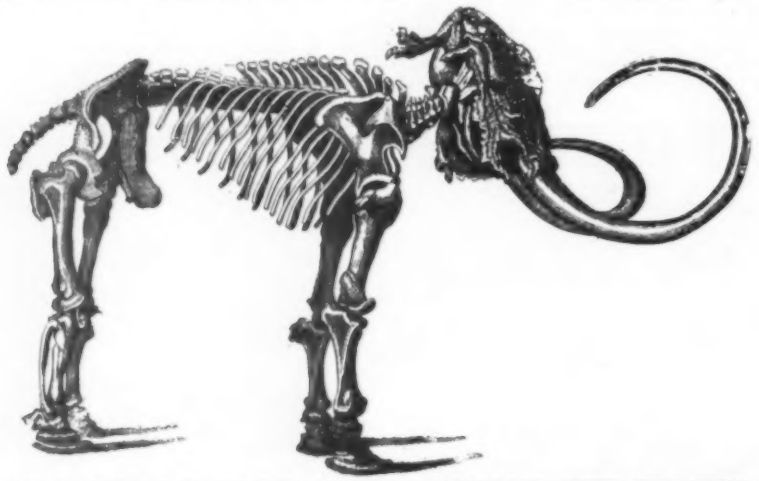


FIG. 1.—SKELETON OF THE SIBERIAN MAMMOTH, WITH THE SKIN STILL ATTACHED TO THE SKULL. (From Jardine.)

At the present day, it need scarcely be said, there are but two living species of elephants, differing remarkably from one another not only in external characters but also, as we shall notice later on, in the structure of their teeth; these two species being respectively confined to Africa and to India and adjacent regions. These two kinds of elephants are, however, merely the last survivors of a vast host of extinct forms, some of which were closely related to their living cousins; while others differed so markedly in the structure of their teeth as to have received the distinctive appellation of mastodons, although they are really nothing but very generalized elephants. These so-called mastodons carry us backward to the middle of that division of the tertiary period of the earth's history known as the Miocene; but when we have reached to that stage all below is dark as regards the elephantine pedigree. And it is, indeed, one of the most remarkable circumstances in palæontology that although we know that elephants belong to the great group of hoofed or ungulate mammals, of which they form a well marked division, yet we have practically no sort of knowledge of the many extinct forms which we presume must have connected them with ungulates of a more ordinary type.

Although the trunk and tusks of elephants form their most striking external features, yet it is not to these that the naturalist looks at first when inquiring into the true affinities and general structure of these animals, since these come under the category of specialized and acquired structures, which tell but little of an animal's past history; he looks rather to the structure of the internal skeleton, which is always of especial value as being that part of the organism which is usually alone preserved in a fossil state. Let us then first turn our attention to the skeleton of these animals, of which we may see examples in our larger museums. The most remarkable feature noticeable in such a skeleton (Fig. 1) is that the various long bones of the limbs are placed almost directly one above another, so as to form nearly vertical columns of support for the body; whereas in ordinary ungulates, such as a horse or an ox, these bones are set very obliquely to one another. Moreover, as a similar vertical position of the limb bones occurs in several old extinct ungulates which are known to be of extremely primitive organization, we may take it that an elephant's limbs are likewise of a primitive type. We have, however, further evidence in confirmation of this primitive structure. Thus elephants differ from all other living ungulates in having five complete toes to all their feet (Fig. 2). Moreover, whereas in other living ungulates (except the little hyrax) the bones of the wrist are not situated in vertical rows immediately over the metacarpal bones of the foot, but, on the contrary, cross and overlap one another, in elephants they have the former relation, with the single exception that the bone marked *l* overlaps the one lettered *id* to a certain extent. This difference may be illustrated by saying that if we were to take a hatchet and chop vertically upward between the third and fourth toes of an elephant's foot there would be nothing to resist the passage of the blade till it reached the bones of the leg, whereas in all other ungulates—the pig, for instance—the blade could not pass through the wrist without cleaving solid bone. Again, whereas ordinary ungulates walk solely on the tips of their toes, and are thus termed digitigrade, while the bones of the toes themselves are more or less elongated, elephants walk on the soles of their feet in the so-called plantigrade fashion, and have very short toe bones. Now since all the large extinct ungulates of the lower Eocene or earliest tertiary period also have five-toed feet, very similar to but still shorter and of even simpler structure than those of elephants, there can be no doubt as to the extremely primitive plan on which the entire limbs of the latter are constructed. As regards, therefore, its limbs and feet, an elephant may be said to be an essentially old-fashioned animal.

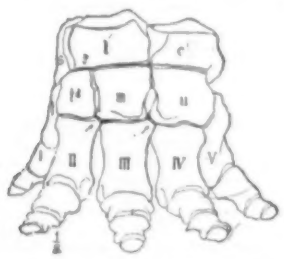


FIG. 2.—BONES OF THE LEFT FORE FOOT OF AN ELEPHANT. (1/8 natural size.)

The lettered bones are those of the wrist or carpus, and the numbered ones the metacarpals, below which are the bones of the toes. (After Osborn.)

If, however, we turn to their teeth, we shall find that elephants are very far indeed from being of a primitive or old-fashioned type; the truth being that they are, on the contrary, very peculiar and specialized in this respect. The first and most obvious peculiarity in regard to their dentition is to be found in their tusks, which correspond to one of the pairs of upper front teeth in man, and also to the single pair of such teeth in the rodents (rats, hares, etc.) Moreover, these teeth, like the incisors of the rodents, grow continuously throughout the life of the animal, owing to the circumstance that the pulp cavity at their base always remains open, and has a permanent connection with the soft structures of the gum. In our own teeth, on the contrary, the pulp cavity closes at a certain period; after which there is a total cessation of growth. These ever-growing tusks of the elephant are preceded in the young animal by a pair of small milk tusks, with a closed pulp cavity, which are shed at an early period of life. In both of the living species of elephant the tusks are confined to the upper jaw; but whereas they occur in both sexes in the African elephant, in the Indian species large permanent tusks are restricted to the male, and are not, indeed, invariably present in all individuals of that sex. The primitive elephants or mastodons, frequently, however, had tusks in both the upper and lower jaws; and since these did not generally attain the huge dimensions which they reach in many true elephants, it is evident that in this respect the mastodons departed less from the ordinary type of mammals, where the front teeth are not greatly larger than the hinder ones, and those of the upper and lower jaws correspond with one another in size and number. Before leaving the subject of tusks, it may be mentioned that the ivory of which they are composed differs from the so-called ivory of other teeth in a manner which renders it always easy to determine whether a reputed ivory article is genuine. This peculiarity consists in the circumstance that a transverse section of a tusk exhibits a series of fine, decussating, curved lines radiating from the center to the circumference, and forming curvilinear lozenges at their intersections. This peculiar structure is in fact precisely similar to the "engine turning" on the back of a watch; and in an ivory knife handle it should be distinctly visible at the butt.

We now turn to the grinding or molar teeth, which present far more remarkable peculiarities, and of which a brief account was given in the article on "Teeth and their Variations," already published in *Knowledge*. So peculiar, indeed, and unique are the structure and mode of succession of the molar teeth of elephants, that they are often very imperfectly understood, even by those who have spent half their lives among these animals. For instance, we find the veteran elephant hunter, Sir S. Baker, in his "Wild Beasts and their Ways," making the statement in regard to elephants that "both the Indian and African varieties have only four teeth," whereas, as a matter of fact, every elephant has, during its whole life, six molars on each side of both the upper and lower jaws. Instead, however, of all these teeth being in use at one and the same time, as are those of a cow or a horse, in existing elephants there are never more than portions of two teeth in use at any one time, although, in the extinct mastodons, portions of three may co-exist. In all elephants, the more anterior of these six teeth are smaller and of simpler structure than the hinder ones, and the whole series is protruded in an arc of a circle from back to front, the larger hind teeth being pushed up and gradually coming into use as the small anterior ones are worn away and finally discarded. The hinder ones of these teeth (Fig. 4) are so large that while the front portion is being worn away the back is still bedded in the gum. In the earlier elephants, or mastodons, these molar teeth are composed of a series of relatively low and widely separated transverse ridges, more or less completely divided into inner and outer moieties, and with large open valleys between them. Moreover, in all the teeth, except the last, these ridges

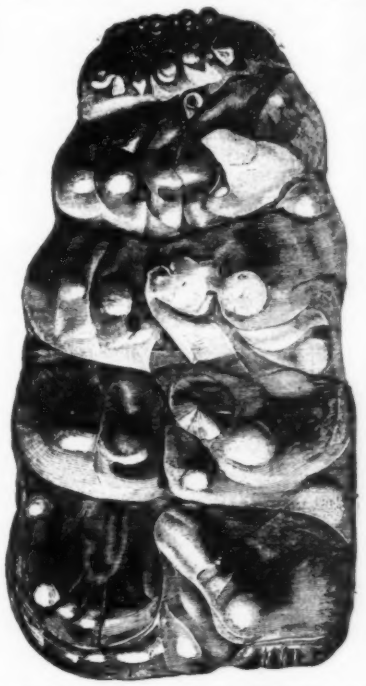


FIG. 3.—LAST OR SIXTH UPPER MOLAR TOOTH OF A MASTODON. (1/4 natural size.)

do not exceed four in number, although in the sixth tooth (Fig. 3) they may be as many as five or six.

It was explained in the article on teeth how such a molar tooth might have been derived from the ordinary type of tooth presented to us by the molars of the pig, in which the crown carries four columns, severally placed at its corners. When a tooth like the one represented in Fig. 3 became worn down by use, the enamel coating each of the columns would be cut through, so as to expose a series of more or less trefoil-shaped surfaces of ivory, each surrounded by a ring of hard enamel. And it will be obvious that a tooth thus constructed of alternations of substances of different degrees of hardness would act as an efficient millstone. Elephants do not appear, however, to have been by any means satisfied with this comparatively simple kind of tooth, for as we pass upward in the geological scale we find that there has been a gradual increasing complexity in the structure of the molar teeth of these animals, this being due to a graduated increase in the height of their transverse ridges, accompanied by an increase in the number of the ridges themselves. There is, indeed, an almost perfect structural gradation, now known to exist between the mastodon tooth, represented in Fig. 3, to the teeth of true elephants shown in Fig. 4. Both the latter examples are in a somewhat worn condition, but it will be readily seen that the lozenge-shaped surfaces of ivory, surrounded by enamel, in the tooth of the African elephant, correspond to the transverse ridges of the mastodon's tooth.

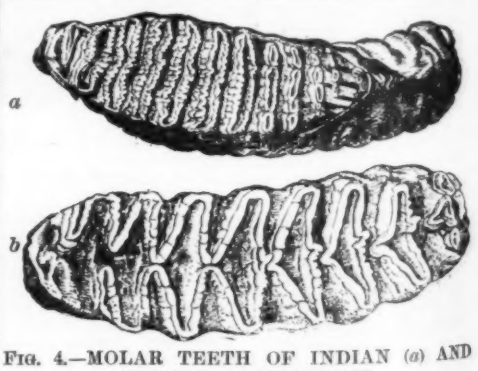


FIG. 4.—MOLAR TEETH OF INDIAN (*a*) AND AFRICAN (*b*) ELEPHANT.

In *a* the anterior half is worn and the remainder unworn. Much reduced. (After Owen.)

In the true elephants, however, the open valleys between these ridges (which have now assumed the form of tall, thin, and nearly parallel laminæ) have been completely filled up by a third constituent of the tooth, known as the cement. The grinding surface of the tooth of such an elephant consequently consists of a solid mass, made up of alternating vertical transverse layers of various substances, arranged in the order of cement, enamel, ivory, enamel, cement; and since each of these constituents differs in hardness, it will be

obvious that the millstone-like apparatus is now of a far more efficient type than it was in the mastodon. Moreover, as the crowns of the molars of the true elephants are very much taller than are those of the mastodons, it is evident that they will require a longer period of time before they become worn away, and that they will therefore allow a longer life to their owner. Even, however, among true elephants there is a considerable amount of difference in regard to the number and narrowness of the component plates of their molar teeth, and it will be seen from Fig. 4 that in this respect the African elephant departs far less widely from the mastodon than does its Indian cousin.

Since the food of the latter consists to a large extent of boughs and twigs, while that of the former is composed more of juicy leaves, fruits, and roots, the necessity of a more complicated masticating apparatus in the one than in the other is apparent.

In modern elephants, the six molar teeth on either side of each jaw are all that are ever developed. This is, however, by no means the case with some of the earlier elephants, and with most of the mastodons. In these animals, when the second and third molars became worn out, they were succeeded vertically by much smaller teeth, from which we learn that the first three molars of the modern elephants really correspond to the milk teeth of other mammals, which, as we all know, are succeeded vertically by some of the permanent series.* This succession of the teeth shows us, therefore, another point in which mastodons tend to connect modern elephants with ordinary ungulates.

We might go further and enter upon the consideration of some of the structural peculiarities presented by the soft parts of elephants. Enough has, however, been stated to show that while these animals have preserved a very ancient type of structure in their limbs, they have acquired a very special modification in the structure and mode of succession of their teeth. And it is highly probable that it is owing to this particular specialization that elephants have survived to our own day, while all the other plantigrade and five-toed primitive ungulates have completely passed away; while it is almost certain that it is this feature alone which has enabled them to attain the gigantic bulk which forms one of their most striking features. In regard to their evolution perhaps no group shows more clearly than that of the elephants how exceedingly important is the study of fossils to elucidate the relations of existing animals. Had we only the two living species of elephants to deal with, we should never have had the least inkling of the manner in which they were related to other ungulates, imperfect as our knowledge of the relationship still is.

Moreover, from the distribution of these two species, it would have been naturally inferred that elephants were creatures suited solely to tropical or sub-tropical climates. The discovery of frozen carcasses of the mammoth—a species closely related to the Indian elephant—in the Siberian "tundras" shows, however, that this animal (Fig. 1) was suited to dwell in at least comparatively cold regions, although it is probable that the climate of Siberia was formerly not so rigorous as it is at present. To withstand the cold of these northern regions the mammoth was protected by a coat of long reddish hair, beneath which was a shorter covering partaking more of the nature of wool. Along the borders of the Arctic Ocean for hundreds of miles mammoth remains are met with in incredible quantities; and it is still one of the puzzles of geology to account adequately and satisfactorily for the manner in which these creatures perished, and how their bodies were buried beneath the frozen soil before decomposition had begun its work, for it is hardly possible to believe that they lived in a climate so rigorous that their bodies would have been frozen on the surface of the ground immediately after death.

Another rude shock to our common ideas of elephantine nature is afforded by the extinct elephants of Malta, which show us that gigantic size is not a necessary concomitant of the group; and that when the area in which a species dwelt was small, the size of the species itself was proportionately reduced. These little Maltese elephants were very closely allied to the living African species, but whereas "Jumbo" attained eleven feet in height, and wild specimens of the African elephant may be still larger, the smallest of the Maltese species was scarcely taller than a donkey. So small, indeed, are the bones and teeth of this species exhibited in the Natural History Museum, that it is sometimes difficult to convince people that they really belonged to elephants at all.

As regards their distribution, elephants and mastodons formerly roamed over the whole world with the exception of Australia; true elephants ranging over the whole of the Northern Hemisphere, while mastodons extended as far south in the New World as the confines of Patagonia. It is in the northeast of India, Burma, and the islands of the Malayan region that the fossil elephants connecting the living species with the mastodons are alone found; and it is thus probable that from these regions the true elephants migrated westward into Europe and Africa, while the mammoth in later times crossed from Asia into Alaska by way of Behring Straits. That the mammoth which ranged from the Arctic regions to the Alps and Pyrenees was a contemporary of the primeval hunters of Europe is now a well-established fact, but it appears that throughout the Old World mastodons had utterly died out before the advent of man. In the New World, however, the continuity between the old and the new fauna was more fully sustained, the Missouri mastodon having survived well into the human period, so that we have in this survival a good instance of the vast changes that have taken place in the fauna of the globe within what we may metaphorically call the memory of man.—*Knowledge.*

THE TEMPERATURE OF THE SUN.

NUMEROUS attempts have been made to determine the sun's temperature, and the results obtained range from 1,500° to 5,000,000°. The enormous differences that exist between the different estimates result from the fact that different laws have been assumed to represent the rate of radiation. M. H. Le Chatelier communicated the latest contribution to the subject at the meeting of the Paris Academy of March 28. His experiments show that the intensity of the radiations emitted by an incandescent body of which the emissive power is unity is expressed by the formula

$$I = 10^{4.4}\, T^{\frac{3210}{T}}$$

The temperatures employed range from 680° to 1,770°, and these, with the observed intensity of radiation, have been used to plot a curve. By extending the curve and measuring the intensity of the radiation from the sun, an estimation of 7,600° as the effective solar temperature is obtained. The term effective temperature is used to express that temperature which a body having an emissive power equal to unity should possess, in order to send out radiations of the same intensity as the sun. The real temperature of the photosphere is higher than 7,600°, because its radiations are absorbed by the cooler solar atmosphere, and it may be, also, because the emissive power of the sun is less than unity.

THE PERUVIAN MOUNTAIN STATION OF HARVARD COLLEGE OBSERVATORY.*

By WILLIAM H. PICKERING.

THE Boyden Department of Harvard College Observatory was founded in the spring of 1887. By the will of Mr. Boyden a considerable sum of money was left to aid in the establishment of an observatory "at such an elevation as to be free, so far as practicable, from the impediments to accurate observations which occur in the observatories now existing, owing to atmospheric influences." Evidently the first duty of those in charge of the fund was to find a suitable locality for the observatory. Accordingly, the following summer an expedition was undertaken to Colorado, well equipped with instruments, and observations successively secured in three localities, namely: Colorado Springs, altitude 6,035 ft.; Leven Lakes (near Pike's Peak), altitude 10,964 ft.; and Pike's Peak, altitude 14,147 ft. At each of these stations a 12 inch Clark refractor was set up, with a portable mounting especially contrived for the purpose. Pike's Peak is probably the greatest altitude at which so large an instrument has ever been used. A quartz spectroscope furnished with two 60° prisms was also employed at each station, and several hundred photographs secured of the solar spectrum. Several of these spectra showed a line at w. l. 292, which is believed to be the shortest wave length yet photographed in any celestial spectrum. The negative which showed this line to the best advantage, however, was one taken from the lowest station.

An examination of the other photographs showed that no perceptible advantage was gained by an increase of 8,000 ft. in altitude, and it was, therefore, concluded that the shorter wave lengths which the sun, in all probability, gives out from his surface, were absorbed before passing through his atmosphere. With regard to the steadiness of seeing, no appreciable advantage over Cambridge was shown at any of the stations. The stars were undoubtedly somewhat clearer than at sea level, but this difference only amounted to a fraction of a magnitude. As a final result of the summer's work, it was concluded that the selection of a proper site for an observatory was by no means merely a question of elevation.

The next expedition sent out by the department was in the winter of 1888–89. Observations with a 13 inch Clark refractor were made at Willows in Northern California, and later on Wilson's Peak, altitude 6,000 ft., in the southern part of the State. The telescope was kept at the latter point for over a year, and continuous observations made every clear night. During the rainless season scarcely a cloud obscured the sky, and the definition was extraordinarily fine. Altogether the station was a decided improvement over Colorado. Nevertheless, there were objections to the location, one being that it was found almost impossible to secure a clear title to any land near the summit of the mountain. For this and other reasons it was decided to seek farther.

In the mean time Messrs. S. I. and M. H. Bailey had undertaken an expedition to the west coast of South America, and had established a station upon Mt. Harvard, altitude 6,600 ft., not far from Lima, Peru. This station was occupied for over a year, and very satisfactory results were obtained at it. It was concluded from theoretical considerations, largely meteorological, into which it is not necessary to go at present, that a desirable location ought to be found near the tropics. The Messrs. Bailey explored the coast as far south as Valparaiso, with this point in mind, visiting also several inland cities. Especial attention was directed to Arequipa, and this city was so favorably reported on that it was decided to send the next expedition to that point.

The present expedition left the United States in December, 1890, arriving in Arequipa the middle of the following January. It was then in the height of the cloudy season, which lasts about four months, and little direct astronomical work could be accomplished. Nevertheless a map of the valley was undertaken, a site for the observatory selected, the land purchased, and the erection of buildings commenced. The clear season opened in April, and soon it was found that the favorable reports given us had in reality far understated the truth. The transparency of the sky was such that it was a common occurrence to see third magnitude stars set below the horizon where it was on a level with the eye, while at home, as is well known, to see any star set, unless behind some elevation, is an unusual event.

But with the 13 inch telescope the most interesting results were obtained. Ten and twelve diffraction rings have been counted, under favorable circumstances, around the brighter stars, each ring being nearly if not absolutely motionless. It is well known that in general to see the rings at all with a telescope as large as the 13 inch is a rare occurrence, and that the few there seen are nearly always wavering and broken. At first a power of 475 was used exclusively for all observations, saving those requiring a large field, this being the highest power with which we came provided. The definition under these circumstances upon the moon and planets was absolutely sharp, and without a blur or waver. Since then higher powers have been sent from home, and 1,140 diameters have been used upon Venus in the day time, that power showing the planet to decidedly better advantage than 812. The phases of Jupiter's satellites are readily observed as they enter into the shadow of the planet, a phenomenon which it is thought but few astronomers have ever seen, even with much larger telescopes than the 13 inch.

This telescope, though small compared to the modern giant refractors, is nevertheless the largest visual refractor in use south of 35° north latitude, although there are about thirty larger ones north of this parallel. This fact has therefore enabled us to study all of the more interesting southern objects for the first time with an instrument of this power. As a result many new double stars have already been discovered, together with several faint clusters and nebulæ which are probably new. Some of our most interesting observations, however, pertain to the bodies of the solar system, which the high magnifications that we are able to employ enable us to study to great advantage. Descriptions of some of these observations we hope shortly to be able to send to *Astronomy and Astro-Physics.* This telescope, as has been mentioned upon former occasions, has the valuable peculiarity that by reversing the crown lens, and shifting the flint, we may convert it from a visual into a photographic telescope, of high excellence. Notwithstanding the great interest attaching to the visual work which may be accomplished here, the photographic results which may be obtained by an instrument of this size, so unusually located, are so much more important that it is very doubtful if many more visual observations can be made with it, and this year its time will be largely devoted to securing spectra of the brighter southern stars.

The city of Arequipa, though the third in size in Peru, having a population of about 29,000, is not well known to the outside world. The visitor arriving at the port of Mollendo passes through a rougher surf than he has probably ever seen upon the Atlantic coast, and takes the cars of the Southern Railway of Peru, one hundred and seven miles across the desert, to his destination. The city itself is situated in a little green oasis containing perhaps sixty square miles, through which runs the river Chile. The observatory is built upon the crest of a hill overlooking the valley, and about four hundred feet above the city. To the eastward lies the extinct volcano of Pichu pichu, 18,600 feet in height, northeast and but ten miles distant lies the quiescent volcano of the Misti, 19,200 ft. in altitude, and to the north, and twelve miles distant, lies Charchaui, 20,000 ft. in elevation. Although these mountains are so near at hand, yet in no case do they rise over 12° above the true horizon.

The true geographical position of the observatory has not as yet been accurately determined, but it is, roughly speaking, in latitude 16° 24′ south, and longitude 4h. 45m. 30s. west from Greenwich. It is consequently about 4,000 miles south of Harvard Observatory and about 18 miles west of it. Its altitude is 8,055 ft. above the sea, and it is therefore considerably higher than any other observatory in the world having so extensive an equipment.

Owing to our location within the torrid zone, our meteorological conditions are very regular. As we have been here but one year we cannot as yet generalize, but we may say that the clear season is expected to begin the latter part of March or first of April, and to continue with scarcely an interruption from cloud until the first of November. November is the beginning of the cloudy season, and during this month this last year 0·02 of an inch of rain fell. December was fairly clear, while January and February were cloudy and rainy. Nearly all the rain falls in January and March, amounting in general to two or three inches in all. The mornings, with few exceptions, are bright and sunny throughout the year, most of the rain falling in the afternoon and evening. Excepting during the rainy season, the climate is exceedingly dry. With some persons the skin becomes rough and the lips crack from the excessive drought. All vegetation is maintained by constant irrigation, for an evaporation of 0·59 of an inch in one day has been recorded in the rainy season. No observations have as yet been made when the weather was really dry. The wind reaches its maximum in the middle of the day, and it is unusually calm at night. The highest velocity noted was December 26, when it reached a velocity of 17·2 miles an hour, but a slight addition must be made to this figure on account of our rarefied atmosphere.

The barometric pressure and temperature are very uniform throughout the year. Tri-daily observations are maintained, and during the clear season a fourth observation is taken in the middle of the night. The highest barometer reading recorded was 22·676 on Aug. 17, and the lowest 22·472 on January 19. The maximum thermometer reading was 79°·0 on June 3, but this was unusually high, the second highest being 74°·3 in October. The minimum thermometer reading of the year occurred eight days after the maximum upon June 11, and was 38°·5. Although the temperature of the air never gets down to freezing, not only do we have occasional frosts, but standing water is known to skim over with ice during the clear season, such is the excessive radiation. The power of the sun is at times tremendous, and a blackened bulb thermometer exposed to its rays in vacuum has been known to reach 164°. We have sometimes had difficulty in our tool room in the afternoon, when the sun shone in, as the tools became so hot that we could not handle them without first putting them in the shade to cool. It is not pleasant to be out in the middle of the day during the clear season, but in the shade, upon our veranda, it is never uncomfortably warm, and the middle of the day there is always a cool breeze blowing. I have gone into considerable detail in describing our meteorological conditions, as I am inclined to think that they have more to do with our favorable seeing than has our elevation of 8,000 feet *per se.* Of course they may be said to depend upon it, more or less, but still we might have the same elevation elsewhere and be very differently circumstanced meteorologically. From my experience with large refractors in different parts of the world, I am inclined to attribute our exceptionally steady seeing more to the excessive dryness of our climate than to any other one cause.

Arequipa, Peru, March 1, 1892.

SAWDUST and shavings, reduced to powdered charcoal, are used in wine to absorb unpleasant odors.

* See article on "Teeth and their Variations."

* Communicated by the author to *Astronomy and Astro-Physics.*

TWO NEW LIQUIDS.

Two new liquids containing fluorine have been synthesized by M. Meslans. They are, says *Nature*, halogen derivatives of glycerin, and were obtained by allowing allyl fluoride, a gaseous substance recently described by M. Meslans, to react with chlorine and bromine. Allyl fluoride, C_3H_5F, is readily prepared by the gradual addition of allyl iodide to dry silver fluoride. It is a colorless gas of peculiar odor, which burns with a luminous flame upon ignition, with liberation of vapor of hydrofluoric acid. When a jet from which chlorine is escaping is brought into a vessel filled with allyl fluoride, combination at once ensues, and drops of a colorless liquid commence to be deposited upon the walls of the vessel. In order to obtain the liquid in greater quantity a large flask is employed, through the caoutchouc stopper of which pass two tubes, one delivering chlorine and the other allyl fluoride. Considerable heat is developed during the act of combination. Hence the flask is immersed in a bath of cold water. A slight excess of chlorine is maintained during the reaction, and the liquid, which rapidly collects, is consequently colored green; but when sufficient has been accumulated, the supply of chlorine is first arrested in order that the excess of that gas, which produces the green coloration, shall be converted to the colorless liquid by the still issuing allyl fluoride and the liquid thus decolorized. The colorless mobile liquid so obtained is then submitted to distillation, when practically the whole passes over into the receiver between 122° and 123°. If the synthetical preparation is conducted volumetrically, it is found that equal volumes of allyl fluoride and chlorine unite; the resulting liquid therefore presumably possesses the composition $C_3H_5FCl_2$, an assumption confirmed by a determination of vapor density which yielded the number 4·50, the vapor density calculated from this formula being 4·51. The compound is indeed a derivative of glycerin, its constitution being probably $CH_2Cl—CHCl—CH_2F$, and may be termed dichloro-fluorhydrin.

The second new compound is analogous to the one just described, and resembles it very closely in properties. It is obtained by the direct union of bromine with allyl fluoride. If a few drops of bromine are allowed to fall into a vessel filled with allyl fluoride, the latter is rapidly absorbed with considerable rise of temperature, the red color of the bromine simultaneously disappearing. To prepare the liquid in quantity, allyl fluoride is allowed to stream slowly into a quantity of bromine contained in a cooled flask, the operation being continued until the red color of the liquid has entirely disappeared. The colorless liquid thus obtained distills without decomposition at 162°—163°. The data afforded by determinations of the bromine content and the vapor density point to the formula $C_3H_5FBr_2$. Both the liquids above described appear to be very stable compounds, for even during their distillation the glass vessels containing them exhibit no signs of etching. They are miscible with ether, and readily soluble in absolute alcohol, but they are almost perfectly insoluble in water. They possess pleasant odors, somewhat reminding one of chloroform, and are sweet but burning in taste. They are incombustible, but at a high temperature the vapors burn with liberation of hydrofluoric and hydrochloric or hydrobromic acids.

NEW SYNTHESIS OF TARTARIC ACID.

SOME light on the natural formation of tartaric acid is afforded by the recent discovery of a simple way in which this acid may be synthesized. A French chemist, M. Genresse, starts with glyoxalic acid—an acid found in gooseberries, grapes, and other fruits—and acting upon it with nascent hydrogen liberated from a mixture of zinc dust and acetic acid, obtains eventually tartaric acid, or rather the optically inactive form of it known as racemic acid, equal molecules of the dextro and lævo varieties being apparently produced. The explanation of the action is very simple. Two molecules of glyoxalic acid are merely brought together by two hydrogen atoms. Glyoxalic acid is $C_2H_2O_3$, while tartaric acid is $C_4H_6O_6$, a formula which, as will be readily seen, contains two molecules of the former acid joined together by two atoms of hydrogen. It is well known that oxalic acid, $C_2H_2O_4$, is formed most readily in vegetable tissues, and is closely related to glyoxalic acid. Having regard, therefore, to the reducing tendencies which are known to characterize chlorophyl, it is not improbable that the natural building up of tartaric acid may be thus explained.

MASRIUM, A NEW ELEMENT (?)

A PAPER has been read before the Chemical Society by H. D. Richmond, in which he states that he and Dr. Off, in the course of an examination of a mineral which is provisionally termed *masrite*, discovered traces of a substance which differed in several important respects from any known metal, and was therefore recorded as a new one under the name *masrium*. This word is derived from the ancient name for Egypt, the mineral in which the supposed new element is found being of Egyptian origin. A sample of masrite analyzed by the authors contained 10·62 per cent. of alumina, 2·56 per cent. of manganous oxide, 4·23 per cent. of ferrous oxide, with small quantities of ferric and cobalt oxides, and 36·78 per cent. of sulphuric anhydride. The balance was made up of water of crystallization, the mineral being an impure manganese alum crystallizing with 22 molecules of water. The quantity of unknown oxide present was 0·2 per cent., and the total amount of mineral available being small, the examination of the properties of the element was less complete than is desirable. The properties as far as they have been determined are as follows: The metal masrium (formula Ms) falls in the second series and twelfth group of the elements when arranged in their periodic order; it has an atomic weight of about 228, and the formula for the oxide is MsO. It gives no precipitate with hydrochloric acid, nor with sulphureted hydrogen in hydrochloric acid solution, but yields a white precipitate with sulphureted hydrogen in the presence of acetic acid. It gives a white gelatinous precipitate with ammonia, insoluble in excess, and similar precipitates with ammonium sulphide and carbonate. With potassium ferrocyanide it gives a white precipitate insoluble in excess of the precipitant, but soluble in excess of masrium chloride.

Potassium ferricyanide yields no precipitate. Oxalic acid gives a white precipitate soluble in acetic acid and in excess of the chloride of the metal. A basic salt is precipitated on boiling a neutral solution of the acetate, but redissolves on cooling. Neutral potassium tartrate gives a precipitate soluble in excess of the precipitant, and from this solution ammonia does not precipitate masrium hydrate. The caustic alkalies give white precipitates soluble in excess. The soluble salts are also white, and of those that have been examined the sulphate $MsSO_4 8H_2O$ crystallizes best, either from its aqueous solution or preferably from 50 per cent. alcohol. This appears to form an alum, in which it takes the place of the potassium sulphate in ordinary alum, and also gives a double salt with potassium sulphate. Efforts to prepare the metal itself have been at present unsuccessful, and further information, notably on its spectroscopic character, is necessary before it can be definitely admitted as a new element.

THE SCIENTIFIC AMERICAN

Architects and Builders Edition

$2.50 a Year. Single Copies, 25 cts.

This is a Special Edition of the SCIENTIFIC AMERICAN, issued monthly—on the first day of the month. Each number contains about forty large quarto pages, equal to about two hundred ordinary book pages, forming, practically, a large and splendid **Magazine of Architecture**, richly adorned with *elegant plates in colors* and with fine engravings, illustrating the most interesting examples of modern Architectural Construction and allied subjects.

A special feature is the presentation in each number of a variety of the latest and best plans for private residences, city and country, including those of very moderate cost as well as the more expensive. Drawings in perspective and in color are given, together with full Plans, Specifications, Costs, Bills of Estimate, and Sheets of Details.

No other building paper contains so many plans, details, and specifications regularly presented as the SCIENTIFIC AMERICAN. Hundreds of dwellings have already been erected on the various plans we have issued during the past year, and many others are in process of construction.

Architects, Builders, and Owners will find this work valuable in furnishing fresh and useful suggestions. All who contemplate building or improving homes, or erecting structures of any kind, have before them in this work an almost *endless series of the latest and best examples* from which to make selections, thus saving time and money.

Many other subjects, including Sewerage, Piping, Lighting, Warming, Ventilating, Decorating, Laying out of Grounds, etc., are illustrated. An extensive Compendium of Manufacturers' Announcements is also given, in which the most reliable and approved Building Materials, Goods, Machines, Tools, and Appliances are described and illustrated, with addresses of the makers, etc.

The fullness, richness, cheapness, and convenience of this work have won for it the **Largest Circulation** of any Architectural publication in the world.

A Catalogue of valuable books on Architecture, Building, Carpentry, Masonry, Heating, Warming, Lighting, Ventilation, and all branches of industry pertaining to the art of Building, is supplied free of charge, sent to any address.

MUNN & CO., Publishers,
361 Broadway, New York.

THE SCIENTIFIC AMERICAN

Cyclopedia of Receipts,

NOTES AND QUERIES.

680 PAGES. PRICE $5.

This splendid work contains a careful compilation of the most useful Receipts and Replies given in the Notes and Queries of correspondents as published in the SCIENTIFIC AMERICAN during nearly half a century past; together with many valuable and important additions.

Over Twelve Thousand selected receipts are here collected; nearly every branch of the useful arts being represented. It is by far the most comprehensive volume of the kind ever placed before the public.

The work may be regarded as the product of the studies and practical experience of the ablest chemists and workers in all parts of the world; the information given being of the highest value, arranged and condensed in concise form, convenient for ready use.

Almost every inquiry that can be thought of, relating to formulæ used in the various manufacturing industries, will here be found answered.

Instructions for working many different processes in the arts are given. How to make and prepare many different articles and goods are set forth.

Those who are engaged in any branch of industry probably will find in this book much that is of practical value in their respective callings.

Those who are in search of independent business or employment, relating to the manufacture and sale of useful articles, will find in it hundreds of most excellent suggestions.

MUNN & CO., Publishers,
361 Broadway, New York.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. ASTRONOMY.—The Peruvian Mountain Station of the Harvard College Observatory.—By WILLIAM H. PICKERING.—Peculiarities of the station, the great dryness of the air, and the peculiarly available qualities of the site. 13685
The Temperature of the Sun.—A recent determination of this factor presented to the Paris Academy.—The formula used and deductions drawn therefrom. 13685
II. CHEMISTRY.—Masrium, A New Element.—A possible new metal, its atomic weight and other factors. 13686
New Synthesis of Tartaric Acid.—Preparation of this acid from natural fruit acid of the gooseberry, grape, etc. 13686
Two New Liquids.—Halogen derivatives of glycerine containing fluorine.—Their properties and preparation. 13686
III. CIVIL ENGINEERING.—A Pond Dredger.—A machine for cleaning out the bottoms of ponds, with a capacity of one ton of sludge at each delivery.—2 illustrations. 13682
Apparatus for Lifting Blocks of Beton.—A hand power crane traversed by horses, used on the work on the port of Boulogne-sur-Mer.—2 illustrations. 13682
A Short History of Bridge Building.—By C. R. MANNERS.—Iron bridges and trusses of the earlier days and of different countries and of the present time.—5 illustrations. 13674
The Portland Cement Trade of the World.—A review of the production of this material from different countries. 13671
IV. ELECTRICITY.—A Domestic Telephone.—A simple telephone for use for short distances.—3 illustrations. 13687
A New Electro-Deposited Alloy.—The "Arcas" plating.—Electro-deposition of an alloy of silver and cadmium.—1 illustration. 13689
Field Magnets.—Salient features of field magnets and the requirements for efficiency.—1 illustration. 13684
Improvement in Dynamo and Motor Construction.—Suppression of the air gap in dynamos and motors, diminishing the reluctance of the magnetic circuit.—4 illustrations. 13692
V. GEOGRAPHY AND EXPLORATION.—Himalayan Glaciers of Baltistan.—The great glaciers of the Himalayas.—1 illustration. 13685
The Great Victoria Falls.—A recent traveler's impression of the great falls of the upper Zambesi River. 13686
VI. MECHANICAL ENGINEERING.—A 4,000 Ton Forging Press.—A hydraulic press.—One of the most powerful in the world.—Used in a French metallurgical works.—1 illustration. 13671
A New Suction Pump.—A very ingenious pump, using a mercury cylinder for piston.—2 illustrations. 13675
Improved Smoke Annihilator.—A system of boiler firing, by which soft coal may be burned with absolutely no smoke.—1 illustration. 13675
VII. METALLURGY.—Aluminum.—By W. R. INGALLS.—All about aluminum.—Its strength, preparation, price and other data. 13676
Researches as to the Properties of Alloys.—By Prof. W. C. ROBERTS-AUSTEN.—A deeply interesting paper, touching on the work done under the auspices of the Alloys Research Committee of the British Institution of Mechanical Engineers.—15 illustrations and diagrams. 13677
VIII. MISCELLANEOUS.—The Homacoustic.—An improved system of speaking tube, especially adapted for use on shipboard.—2 illustrations. 13681
IX. NAVAL ENGINEERING.—The New French Torpedo Cruiser Wattignies.—A high speed ship recently added to the French navy.—1 illustration. 13678
X. RAILROAD ENGINEERING.—The Government System of Railways in Sumatra.—A new railroad system, comprising sections of steep grades, with racks for surmounting them.—2 illustrations. 13683
The Railway between the United States and South America.—The results attained by the surveys of the Inter-Continental Railway.—2 illustrations. 13682
XI. VITICULTURE.—Mildew of the Grape.—A remedy for mildew. With formula of a curative mixture. 13681
XII. ZOOLOGY.—Elephants, Recent and Extinct.—By R. LYDEKKER.—The Siberian mammoth and mastodon.—Their peculiarity of structure graphically told of.—4 illustrations. 13684

A New Catalogue of Valuable Papers

Contained in SCIENTIFIC AMERICAN SUPPLEMENT during the past ten years, sent *free of charge* to any address. MUNN & CO., 361 Broadway, New York.

Useful Engineering Books

Manufacturers, Agriculturists, Chemists, Engineers, Mechanics, Builders, men of leisure, and professional men, of all classes, need good books in the line of their respective callings. Our post office department permits the transmission of books through the mails at very small cost. A comprehensive catalogue of useful books by different authors, on more than fifty different subjects, has recently been published, for free circulation, at the office of this paper. Subjects classified with names of authors. Persons desiring a copy have only to ask for it, and it will be mailed to them. Address

MUNN & CO., 361 Broadway, New York.

PATENTS!

MESSRS. MUNN & CO., in connection with the publication of the SCIENTIFIC AMERICAN, continue to examine improvements, and to act as Solicitors of Patents for Inventors.

In this line of business they have had *forty-five years' experience*, and now have *unequaled facilities* for the preparation of Patent Drawings, Specifications, and the prosecution of Applications for Patents in the United States, Canada, and Foreign Countries. Messrs. Munn & Co. also attend to the preparation of Caveats, Copyrights for Books, Labels, Reissues, Assignments, and Reports on Infringements of Patents. All business intrusted to them is done with special care and promptness, on very reasonable terms.

A pamphlet sent free of charge, on application, containing full information about Patents and how to procure them; directions concerning Labels, Copyrights, Designs, Patents, Appeals, Reissues, Infringements, Assignments, Rejected Cases. Hints on the Sale of Patents, etc.

We also send, *free of charge*, a Synopsis of Foreign Patent Laws, showing the cost and method of securing patents in all the principal countries of the world.

MUNN & CO., Solicitors of Patents,
361 Broadway, New York.

BRANCH OFFICES.—No. 622 and 624 F Street, Pacific Building, near 7th Street, Washington, D. C.